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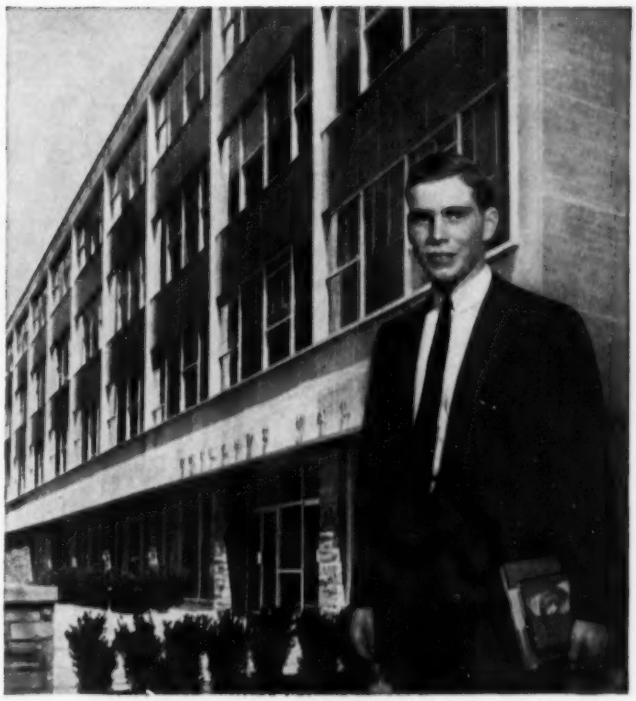
Herschel Loomis asks:

What are my chances for advancement in a large company like Du Pont?



Herschel H. Loomis, Jr., will receive his B.S. degree in electrical engineering from Cornell University June 1957. Herschel is a member of the freshman and varsity rifle teams, an associate member of Octagon, a dramatic group, and belongs to Theta Chi Fraternity. Like many other students, he's making employment plans early.

Peter J. Meshkoff joined Du Pont at the Jackson Laboratory in 1941, after obtaining a B.S.Ch.E. from the University of Detroit and an M.S. from the University of Michigan. He has had a wide range of Du Pont experience, from chemist in the Dye Works to chief supervisor and works engineer at several plants, with many opportunities to observe Du Pont personnel policies. Today Pete Meshkoff is works engineer at Du Pont's new Film Plant at Circleville, Ohio.

Peter Meshkoff answers:

Your question is a natural one, Herschel—one we hear quite often. Du Pont is unquestionably a large company in total number of employees and in all its operations. But, actually, Du Pont is made up of ten independent departments, almost as if it were ten companies under one management. And it is a fundamental policy at Du Pont to promote from within and on merit only.

That produces many opportunities for new men, but in addition there are proportionately more promotions at Du Pont each year—by reason of expansion and retirement—than you would find in most smaller companies. I say "proportionately more" because Du Pont has grown at an average rate of seven per cent a year for the past 153 years—a record that few companies can match.

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WANT TO KNOW MORE *about the opportunities for growth touched on by Pete Meshkoff? Send for a free copy of "The Du Pont Company and the College Graduate," which discusses many of the employment policies and activities of Du Pont in detail. Write to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington 98, Delaware.*

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Editorial -

Engineers & Activities:

The value of "Project to Greece"

The role of student activities in building a balanced, complete individual is a significant part of Cornell life. No student can gain the full potential of college education through studies alone. The cultivation of some particular talent, the development of a working sense of teamwork, and the creative satisfaction of contributing constructively to the University community must be an intrinsic part of the formative college years. This need for growth beyond course material is of prime importance to the engineer.

The rigid curriculum presented to engineering students offers little chance for development in the vital areas of personal awareness and social responsibility. There is no question that the phenomenal rate of change in science and engineering development requires comprehensive and thorough grounding in basic and applied technical courses. The engineering student of today must of necessity master his college courses if he is to become an effective leader in his profession in the future.

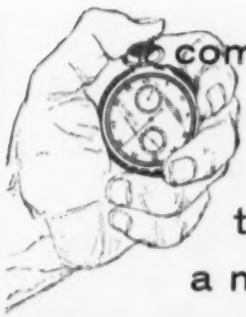
But the world of technology in which today's engineering students seek to assume a useful place will offer an even greater challenge because engineers will be needed as leaders in every area of society. Management, government, labor, and community, will rely on the perception and initiative of technically trained people to solve more problems and to mold more actively the economic and social progress of our nation. Thus the engineering student must strive to develop abilities beyond the discipline of his professional knowledge. He must use to their fullest advantage the opportunities for such development offered by worthwhile extracurricular activities.

"Project to Greece" sponsored by Cornell United Religious Work, is an excellent and distinctive example of an activity that can broaden a student's awareness of the needs and aspirations of his fellow men. The project is a mission from Cornell University to the American Farm School in Thessalonika, Greece, during the coming summer months. Its purpose is the construction of a conference center-dormitory for the school. Thirty-two Cornell students will cooperate with students from Europe and the Middle East to erect the building, using tools and plans provided by the Farm School. The efforts of the participating students will significantly contribute to the school's effectiveness in providing four year agricultural training for young men who will ultimately be leaders in the rural communities of Greece.

Chairman of the Project to Greece is Alfred Mitchell, ME '56. Al Mitchell's work reflects a concern for devlopment of the total self and for learning teamwork on an international basis. This experience will be of lasting value to him as a practicing engineer and to each student in the group that travels to Greece this summer.

The CORNELL ENGINEER wishes every success to Project to Greece. We hope that more such opportunities for students to gain a working knowledge of human relations will be undertaken in the future. Above all, we encourage engineering students to participate in such activities to the fullest possible extent, in order that they may develop a balance of leadership abilities that gives meaning and purpose to their technical training.

R.G.B.



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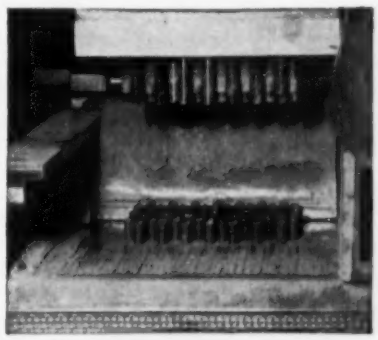

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LEE De FOREST

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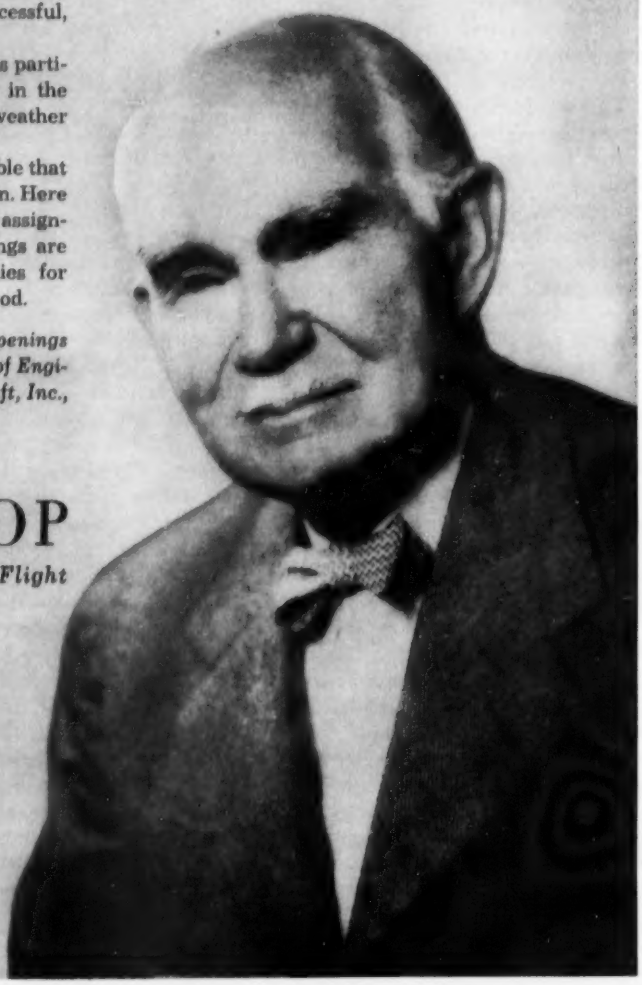

*A statement by Dr. Lee de Forest, pioneer in radio.

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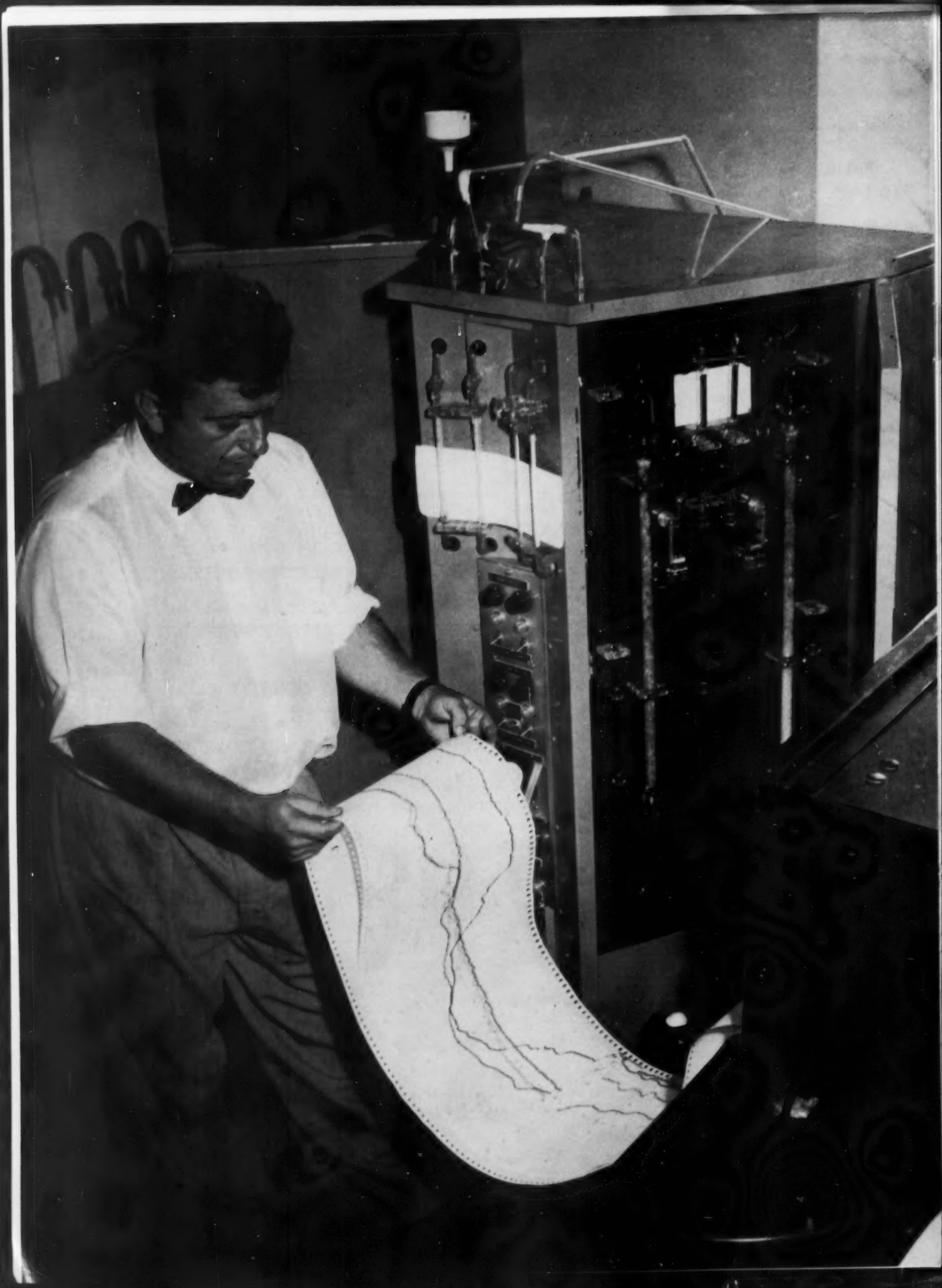


SMOG : Los Angeles and Your Community

by

ALAN S. ROSENTHAL, EE '60

It took many years before we began to realize that our natural resources are limited. Now everyone knows that the minerals we take for granted are coming from an ever dwindling supply. Although we realize that our natural resources can eventually be exhausted, we seldom put the air we breathe into the category of a natural resource. Air is something everyone takes for granted, yet recent conditions in many parts of the world lead us to question the idea of air being something that can never be used up. The Los Angeles smog problem, which has been in the headlines quite often, has led many scientists to investigate our limited supply of air.

Smog is not the problem of Los Angeles alone. As long ago as 1257, "coal smoke" was known to plague England. In fact, laws were instituted in England as early as 1273 to control the flow of contaminating materials into the air. Indeed, smog has been a perennial problem in England and is known to cost the country as least fifty million pounds per year, to say nothing of the loss of life indirectly caused by smog conditions.

When we think of smog in Europe, we automatically think of England, but many other countries suffer from smog problems. In Belgium in December of 1930, a five day "fog" caused untold suffering to hundreds of people. In Poza Rica, Mexico, on November 24, 1950, twenty-two people died as a result of atmospheric pollution in that refining town. The list of areas afflicted seriously by smog is long and includes many Canadian cities as well as cities in our country.

The problem in Los Angeles, although the result of some rather unusual conditions, must be regarded as something that could happen to our own town or city under a given set of circumstances. Los Angeles' actions toward the elimination of smog show the preventative measures many of our own towns should take and some of the measures that can be taken to alleviate any smog conditions that may already exist.

Activity of four pollutants in Los Angeles Basin are recorded on graph paper shown in one of the many machines being developed to measure air pollution.

Conditions Contributing to Smog

All industrial cities are subject, to some extent, to man-made pollution of the atmosphere. Los Angeles and its environs, however, have special and peculiar problems. Los Angeles County is the largest heavily industrialized, semi-tropical area in the world. Its population has more than doubled since 1939, and industry has expanded from approximately 1,500 establishments with processes capable of emitting air contaminants to some 12,000 such establishments in 1954.

Topographical and meteorological conditions aggravate the effects of the pollution produced by this population and this industry in the Los Angeles Basin. High mountain ranges hold the polluted air in on the north and northeast. Prevailing winds during most of the year are westerly or southwesterly during the day time. The average wind velocity is less than six miles per hour. Even this small breeze dwindles to almost nothing in the later part of the day.

The absence of winds to carry away pollutants plus the frequent presence of temperature inversions make the Los Angeles area a perfect region for smog to accumulate. Temperature inversions occur when a layer of cold air is trapped beneath a layer of warm air. When this inversion layer descends over Los Angeles to a height of less than 1000 feet, the 34,000 tons of garbage that are belched into the Los Angeles skies cannot be carried away.

The logical thing to do in order to rid the city of smog would seem to be to remove the inversion layer. The removal of the layer would be no easy feat. It was found that, in order to clean the air by the creation of artificial wind movements or by breaking the layer, the total power produced by Hoover Dam for 3½ days would be required. Such power was, of course, not available.

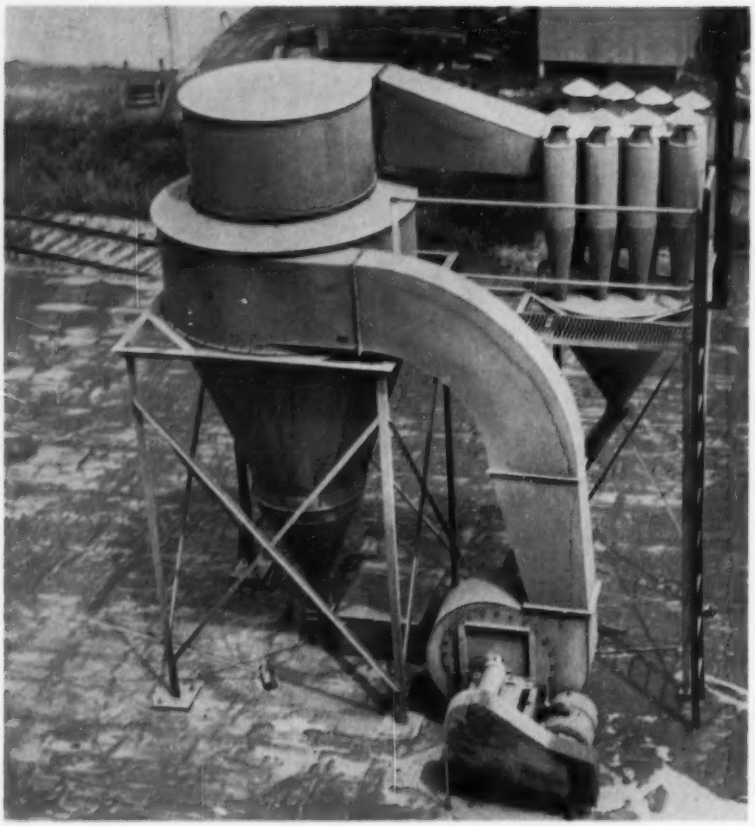
The second possibility for the removal of smog was the elimination of the source. At first, the community tried to control the wastes produced by its many refineries. It was soon discovered that the indiscriminate elimination of wastes would not be the answer. In fact, with the refinery wastes eliminated, smog continued to increase. Investigators soon realized that it would be necessary to analyze the tons of garbage that poured into the sky to discover its components. Once the components of the smog were determined, their relative concentrations would have to be investigated.

Composition of Smog

Dusts, fumes, smoke, peroxides, aldehydes, organic acids, sulfur dioxide, oxides of nitrogen, and certain hydrocarbons are the principal ingredients of the polluted air. Dusts, fumes, and smoke are significant because they greatly reduce visibility. Many of these particles are usually so small that they remain suspended in the air for long periods of time. All of the sources that discharge these small particles contribute to the poor visibility which accompanies smog.

When sulfur dioxide combines with oxygen, sulfur trioxide is formed. It has been determined that sulfuric acid mist, formed from sulfur trioxide and moisture in the air, is responsible for about one-third of the total reduction in visibility.

Aldehydes in smog have led researchers to a very interesting discovery. These aldehydes, which have been suspected of contributing to



A high efficiency centrifugal collector used to collect dust from flour mills.

eye irritation, have been detected in air in concentrations of 0.4 of a part in a million parts of air. Surprisingly, Los Angeles County can account for only 0.1 part per million. This leads one to the conclusion that approximately 0.3 part per million of aldehydes are formed by complex reactions in the air—reactions that could occur in any town!

Organic acids exist in the air as aerosols and vapors. They are responsible in part for reduced visibility and may contribute to eye irritation. As in the case with the amount of lower aldehydes found in the air, the amount of organic acids directly traceable to sources is not sufficient to produce the quantity measured in the air. Thus some organic acids are formed in the atmosphere. Organic peroxides are also present. Their origin is likewise to be found in the interreactions of certain pollutants in the air.

The aldehydes, organic acids, and organic peroxides are part of the products which are formed when certain hydrocarbon vapors, such as gasoline vapor, are oxidized in the presence of sunlight. Experiments have demonstrated that these products of oxidation produce damage to vegetation. Eye irritation and odors similar to those experienced on days of intense smog are also experienced when small concentrations of unsaturated hydrocarbons are oxidized in a test chamber. The reaction is aided by oxides of nitrogen in concentrations present in the atmosphere. The unsaturated hydrocarbons, therefore, are designated as contaminants.

The Harmful Effects of Smog

Offensive odors that contribute to local nuisances can generally be found in the vicinity of industrial establishments processing fertilizers, meat, fish, rubber, soap, paint, and varnish. Certain chemicals and petroleum products may also be offensive to a neighborhood. Smoke, fumes, and dusts, while adding to the smog by reducing visibility, can also be classified as nuisance problems when the material settles on nearby property. Of importance in this particular field is the damage to property and the inherent nuisances associated with the burning of rubbish in obsolete type incinerators and in the open.

Knowing the components of smog, researchers were faced with the extremely difficult task of determining the specific effects of each component. Nine new instruments have been developed for the specific purpose of analyzing the pollution in air. One of the most advanced of these instruments is a "four-in-one" measuring device. This instrument measures the concentration of four pollutants—oxidants, oxidant precursors, nitric oxide, and nitrogen dioxide. This instrument records the amounts of pollutants in the atmosphere on a single roll of graph paper, allowing scientists to make side-by-side comparisons which otherwise would be extremely difficult and time consuming. The "four-in-one" measuring instrument combined three separate devices which had been introduced in the battle against smog during the previous year.

Another instrument which investigators recently developed is an ozone radiometer. This is a photoelectric device that measures the amount of ozone in the air at any given time. The instrument, operating automatically around the clock, consists of a projector shooting ultraviolet rays across a short space to a receiver. Because ozone absorbs ultraviolet rays, scientists can determine how much ozone there is in the air by measuring how much ultraviolet light is removed as it travels from projector to receiver. Since ozone is one of the most important constituents of smog, the information this machine makes available is extremely valuable.

Another important instrument that has been developed is one for measuring the concentration of carbon monoxide in the air. Several such instruments had already been on the market, but they could only record very large concentrations. The scientists' job was, therefore, to produce a model with stepped up sensitivity. This was accomplished by the addition of pressure cells which now make it possible to tell from any unusual concentration of carbon monoxide in the air

whether a high proportion of the pollution in the air over a given area is from motor vehicles.

A hydrocarbon recorder is another vitally needed instrument in the critical search for all sources of smog, since hydrocarbons are suspected members of the chemical conspiracy in the sky which produces eye irritation and plant damage, and since the amount of hydrocarbons in Los Angeles air is still an unknown quantity. Scientists have succeeded in building a laboratory model of just such a device, and they are now in the process of testing it. This instrument, the first of its kind, will be capable of measuring and recording the concentrations of hydrocarbons which escape during the manufacture and use of gasoline and other petroleum products. The main problem now facing investigators working on this instrument is the development of an economical and efficient method of turning out a usable field model.

This combination of seven automatic instruments has been used in the battle against invisible gases in smog. An eighth instrument has been developed to determine the type of particle matter that is going into the air and, on some days, causing reduced visibility. This eighth instrument is now undergoing laboratory tests. Once it is in operation and investigators are able to find out what sizes of particulate matter are in the air on a smoggy day, they can attempt, in the laboratory, to subject the various size groups to chemical analysis and thereby begin to trace their origin.

Dr. Lewis Rogers, Air Pollution Foundation Chemist, adjusts a new instrument built to continously measure and record hybrocarbons in the air.

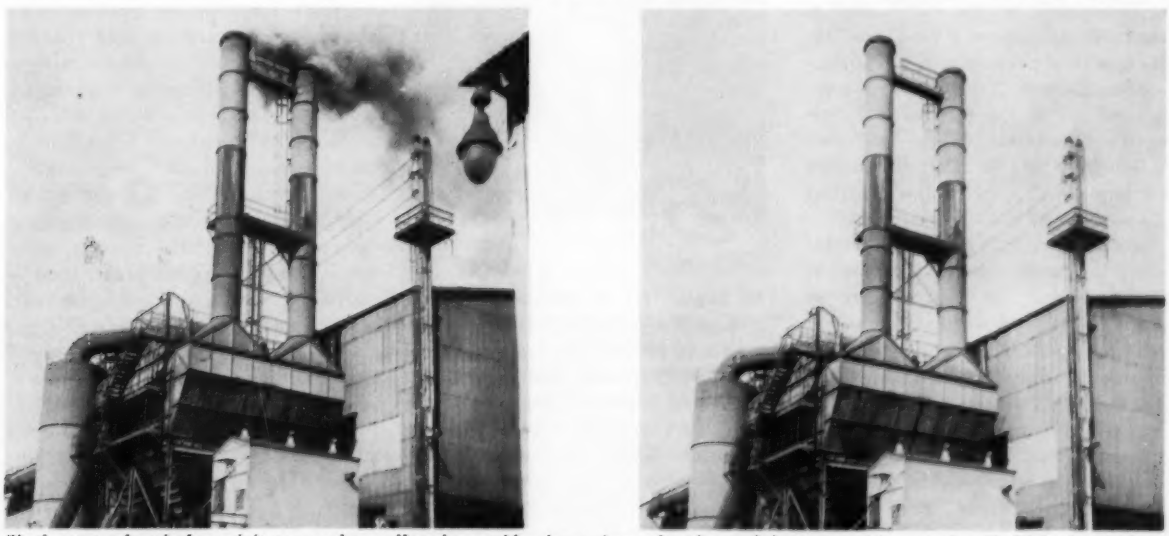
The ninth instrument brought into smog investigation is expected to answer many questions about the inversion layer which still plagues smog researchers. This device is a specially constructed aerometeorograph weighing only one pound, which can be attached to small captive balloons to probe the atmosphere at various levels and bring back continuous readings on temperature, air pressure, and relative humidity.

Counteracting the Smog

In developing these methods to analyze smog, research workers have come a long way in their battle against air pollutants. Unfortunately they still have much more work to do before the smog problem can really be alleviated. Indeed, the Los Angeles Air Pollution Foundation has frequently warned that the smog menace will have to get worse before it can begin to get better. The second phase of the researchers' job has been the development of instruments to counteract the smog—instruments that can actually take the contaminated air and purify it.

Among the devices used for this purpose is a centrifugal separator. This instrument is widely used to collect dust. The machine pulls the contaminated air into a cylinder and revolves it at high speeds caus-

(Continued on page 34)



Single stage electrical precipitator used to collect iron exides from three electric steel furnaces with controls off. Right hand photo shows one unit with controls on.

THE CHANGING ASPECTS OF SALES ENGINEERING

by

by ROSCOE H. FULLER, ME '24

It has been felt over a considerable period of years by those not directly concerned that Sales Engineering is a sort of "stepchild" of the engineering profession. Many whose activities are limited mostly to research or design functions have felt this way, and the ordinary engineering curriculum with its emphasis on the technical has tended to stimulate such views.

It is unfortunate, perhaps, that until recent years no serious effort has been made to protect the term "Engineer," and to restrict its use to those properly qualified to carry it. Thus we have a variety of more or less skilled artisans who have been allowed to refer to themselves as engineers, and many commercial travelers who seek additional dignity by wrongfully attaching to themselves a professional title. It is not these of whom I speak, but rather of the trained engineer whose technical ability, skills and concentrated effort are applied to the furthering of increased knowledge, better methods, and wider distribution of the fruits of industry. The thoughts which I express apply generally to the capital goods industries, and with especial emphasis to the machine tool field. It is in these industries that the term "Sales Engineer" first came to be used.

Sales Engineering is the firing line of engineering activity. As the Infantry, though supported by Artillery, Air and other branch and service forces, has been described as the "Queen of Battle," so can Sales Engineering be described in the technical field.

Being perfectly aware of the storm of protest such a statement will arouse from a dozen quarters, let us reflect for a moment. The Design Engineer can justifiably say that without the product of his skill there would be nothing to sell. The Industrial Engineer can equally well emphasize the importance of proper manufacturing methods, plant layout and so on in bringing a product to the point of sale. Without the Production Engineer, materials, manufacturing, and assembly could hardly be coordinated to a point where the goods produced would reach the market at an economic cost.

Sales Engineering, on the other hand, must combine most of the abilities of these three men with a thorough knowledge of engineering economics, market anaylsis, and cost control. The Sales Engineer, in other words, must be versatile. That versatility is enhanced by his continuous immersion in other people's problems. He spends more time in other people's plants than in his own. His advice is sought (and respected) in dozens of different fields. He may, on occasion, spend time and effort in persuading one of his customers that another method and/or type of machine is more suitable for a given job than his own if he believes such to be the case. His interest lies not in *selling*, but in advising, in recommending; in short, in providing an Engi-

ABOUT THE AUTHOR

Mr. R. H. Fuller

Mr. Fuller is Branch Manager for The Heald Machine Company of Worcester, Massachusetts. During his undergraduate career he was a member of the Widow board, the C.U.C.A. cabinet, the Pistol Team, a Lieutenant in the ROTC and a member of Sigma Alpha Epsilon. He is a past president of the Lackawanna Cornell Club of New Jersey, a member of the McMullen Scholarship Committee, of the Executive Committee of the Cornell Society of Engineers, and of the Steering Committee of the Class of 1924.

Upon graduation, Mr. Fuller went to work for Rolls-Royce of America, Inc., at their factory at Springfield, Massachusetts, where after completing an apprenticeship course he became Assistant Chief Engineer. Moving to Heald in 1929, he worked successively in Engineering, Estimating, Pricing, Sales Engineering, Market Analysis, and as Editorial Writer and Service Manager. He transferred to outside sales in 1937 and has served as Supervisor of Dealer Relations and as Manager in Davenport, Detroit and New York.

Mr. Fuller holds professional engineering licenses in New York and New Jersey, is a member of the American Society of Tool Engineers, The American Management Association, and a former member of the Society of Automotive Engineers.

neering service.

He is a true specialist in the exercise of good engineering judgment in the best interests of his customers. For, while he must naturally never lose sight of his own company's interests, in the final enlightened analysis his company's and his customers' best interests usually prove to be identical.

Limits on Sales Engineering

The scope of Sales Engineering in the Machine Tool Industry is almost limitless; particularly in view of the current trend toward automation and the "totally engineered" plant. Time was, and not so long ago, that a production engineer in a manufacturing plant operated pretty much on his own. He was given a part to produce to a specified tolerance at a given rate. He would then organize his planning by calling in representatives of the suppliers of primary operation machines such as lathes, screw machines, drill presses or what not. In successive groups he would call in suppliers of increasingly specialized equipment until he got to the precision finishing operations. His work consisted largely in evaluating and integrating the competing and often divergent recommendations of a number of individual specialists. He knew when to contact the materials handling people and could visualize the setup on parts inspection. He usually had to decide upon methods, to lay out successive operations in detail and to design jigs, fixtures, and tooling. He fathered the job in all its aspects.

Today, the procedure is changing. The only question to the suppliers is, "Who is competent to take on the job?; "Who'll stretch his imagination enough to visualize the entire line?"; "Who'll take an operations not normally associated with the operation of his basic equipment?"; "Who'll see that the materials handling people and the gauge manufacturers can tie in with the setup?"

Requirements of a Sales Engineer

What kind of a Sales Engineer can handle such a project? Certainly not the man who sells from a catalogue, although he may have one in his brief case. Not just the social type who knows how to order an expense account dinner, although he must be cordial and hospitable without superficial show. Certainly not the man who is so stultified in accepted engineering procedure that he can't recognize a good new idea.

Application Engineering starts with the customer's part and print. Here engineers study a customer's problem first hand before recommending and proposing the equipment which will best suit the exact requirements in the field.

Certainly this man must be communicative. He must be facile in the accurate interchange and transmission of thoughts and information. He must be able to make an economic analysis to determine the wisdom or otherwise of a proposed method of attack. He must be able to meet on equal terms and to talk the language of all levels of operating people, from presidents to machine operators. All of these things are requisite to the successful Sales Engineer. His is the field of contact. He is in a sense the catalyst which, when brought into contact with two reactive situations representing a need and a source of supply, makes the reaction take place.

Too tough a goal?

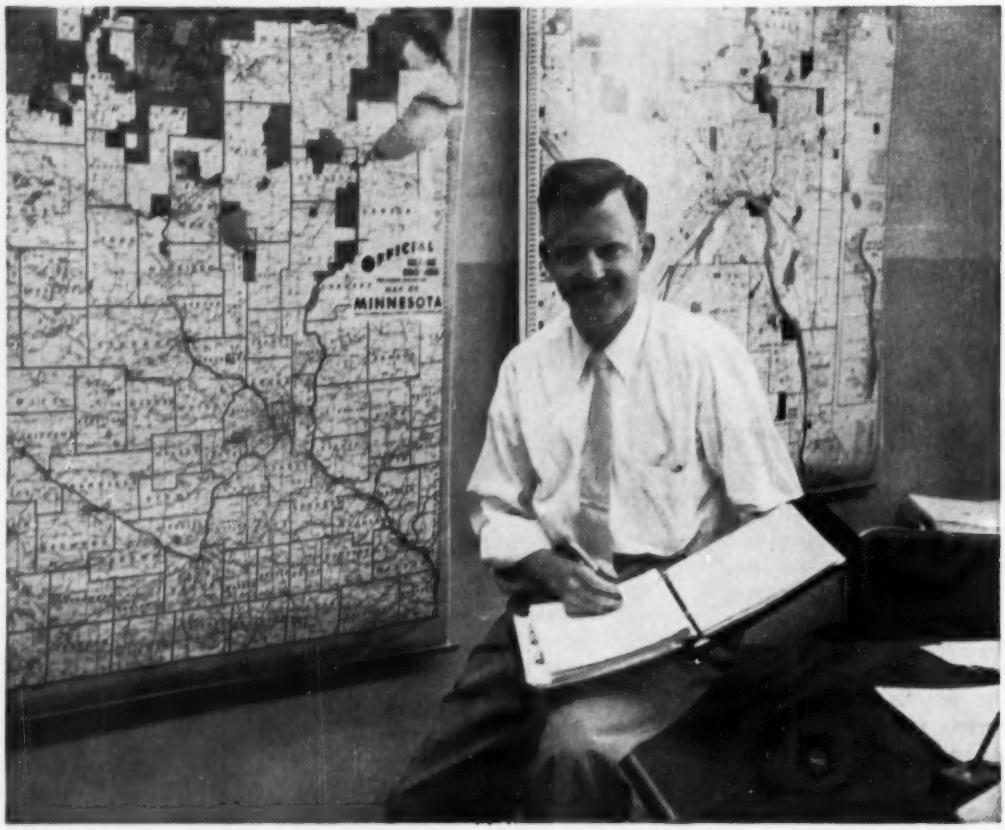
Possibly so, if the attitude of many engineering students and recent graduates is an indication. Too many of our young engineers tend to skirt the real problem and avoid the sales arena under the mistaken impression that other avenues of activity more nearly represent "Pure Engineering," and that the commercial aspects of the field carry a certain materialistic stigma. That this is not true and that the orderly mind and logical approach of the trained engineer can be as useful to mankind in the broad area embraced by Sales Engineering can be exemplified by the increasing numbers of engineers we find in administrative, executive and management positions.

Customer contact brings out the best a man can offer. It involves, even requires, a degree of versatility, presence and all-around knowledge of his field which is far above that required of a man (even one of equal technical proficiency) who can sequester himself behind a desk or a drawing board, or in a research laboratory.

The development of one's abilities in this field can be by far the most rewarding in the satisfaction of a job well-planned and accomplished. It combines the teamwork of one's group with a high degree of individual independent effort for its most successful and effective conclusion. It is perhaps for these reasons that the Sales Engineering field often brings higher material rewards to its successful exponents. The personal attributes described above do have a definite (and recognized) market value.

Sales Engineering well merits the serious consideration of all who intend to embark upon an engineering career.

A Campus-to-Career Case History



"One open door after another"

"When I joined the telephone company," says Walter D. Walker, B.E.E., University of Minnesota, '51, "I felt I could go in any direction. And that's the way it has been.

"For the first six months I was given on-the-job training in the fundamentals of the telephone business—how lines are put up and equipment installed. Learning those fundamentals has paid off for me.

"Then I had the opportunity to go to the Bell Laboratories in New Jersey. I worked on memory crystals—ferro-electric crystals—for use in digital computers. I learned how important research is to the telephone business.

"After two years I came back to Minnesota, to St. Cloud, to work in the District Plant Engineer's Office. There I made field studies of proposed construction projects and drew up plans to guide the construction crews. This combination of inside and outside work gave me invaluable experience.

"In July, 1955, I came to Minneapolis as an Engineer in the Exchange Plant Extension Engineer's Office. We do forecasting—not of the weather, but of future service needs. Using estimates of growth and economic studies, we make our plans for the years ahead. We figure out where and when new facilities will be needed to meet future growth.

"All this has been preparing me for a real future. You see, the telephone company is expanding by leaps and bounds. That's why it offers a young man so many open doors."

Wally Walker's career is with Northwestern Bell Telephone Company. Many interesting career opportunities exist in other Bell Telephone Companies, Bell Telephone Laboratories, Western Electric and Sandia Corporation. Your placement officer has more information regarding Bell System companies.

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Radiochemical Research at Cornell

by ROBERT T. BRADEN, EP '57

Man has learned to release and control the energy bound up in the atomic nucleus. A stupendous amount of manpower, brainpower, and resources have been poured into the scientific research program which taught us how to unlock the atom's energy. It is only natural that such a large scale research program should have important offshoots leading to advances in other branches of science. One of the most important of these scientific by-products of the atomic energy program is the availability of radioactive tracers in great variety and large quantity.

Radioactivity occurs naturally in the world around us; the most familiar examples are radium and uranium. Indeed, if there had been no natural radioactivity for physicists to study, the atom bomb would still be far in the future. However, radioactive substances did not become important research tools outside the field of nuclear physics until the physicists learned to produce artificial radioactivity. Today, using cyclotrons, synchrotrons, and a host of other impressive "-trons," as well as atomic piles, they are able to make a multitude of artificially radioactive substances, or "isotopes," many of which are useful as tracers.

When these radioactive tracers began to be available in large quantities a few years ago, they were hailed as an important tool for biochemical research; since then, they have achieved this and much more. Tracers have practically revolutionized biochemistry and have become useful experimental tools in practically every branch of the natural and biological sciences. A new science, known as radiochemistry, has arisen, encompassing both the use of chemistry for processing radioactive substances and tracers, and the applications of tracers to chemical research.

Professor Diamond inserting a radioactive sample vial into the scintillation counter. The associated electronic circuitry on either side include amplifiers and scalers to record the radioactivity. The lead bricks surrounding the counter eliminate spurious counts from cosmic rays.

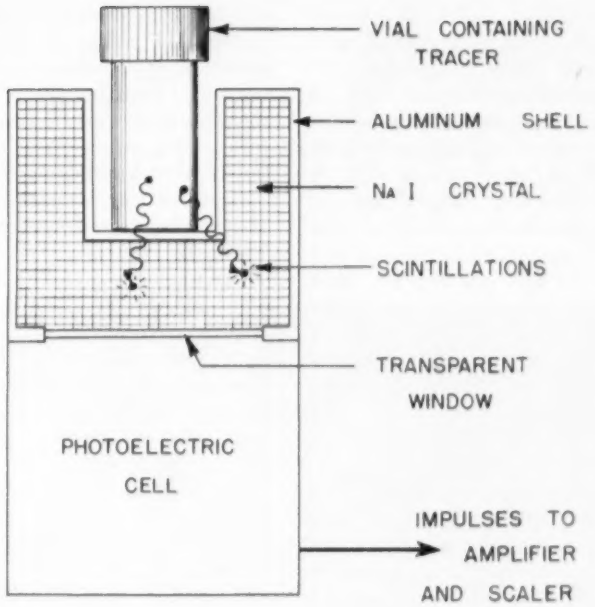
Research at Cornell

Professor R. M. Diamond of the Cornell Chemistry Department is carrying out reseach in the field of radiochemistry. He is using radioactive tracers as a means of investigating the chemical phenomena of ion exchange resins, solvent extraction of metallic ions, and complex ion formation. At present the operation of these processes is not well understood, partly because there has not been enough experimental data upon which adequate theories could be based. Professor Diamond is gathering needed data and hopes to formulate theories to explain these processes more completely.

This research is purely scientific, aimed only at a better understanding of the laws of nature as they operate in chemistry. On the other hand, the results of the research may be of great industrial importance, both for chemical engineering and for radiochemistry itself. Solvent extraction and ion exchange are important industrial processes; they are also, in fact, vital analytical tools of the research chemist. For example, solvent extraction is being used on a very large scale by petroleum refineries for dewaxing gasoline. Research is being carried out in the Cornell Chemical Engineering School and elsewhere on other industrial uses of solvent extraction, which is considered a promising but still relatively undeveloped process. Ion exchange resins are perhaps best known for water softening and in the refining of sugar, but they

are being used for a multitude of difficult separation jobs in the chemical industry. A more complete understanding of the mechanism of these two processes would therefore be of practical importance to chemical engineers.

Some of the more unusual but vital applications of ion exchange and solvent extraction are in radiochemistry, where they are important in the chemical preparation and purification of fuels for atomic reactors, and for the preparation of radioactive tracers. In fact, Professor Diamond uses one of the processes which he is investigating, solvent extraction, for the preparation of radioactive tracers for use in his experiments.



Schematic drawing of scintillation counter used to detect gamma-rays from radioactive tracer.

Radioactive Tracers

One of the most interesting aspects of his research project is the use of radioactive tracers. In order to understand how and why tracers are used, we must review the meaning of "radioactive isotopes."

It is common knowledge that all matter is made up of the basic chemical substances called "elements," and that each element consists of identical atoms which always have the same "Atomic Number." That is, all the atoms of a particular element have the same number of positively charged protons in their nuclei, and an equal number of negatively charged electrons in the space surrounding the nuclei. The number of electrons, and therefore the Atomic Number, determine the chemical behavior of a particular element so that all the atoms of an element behave the same chemically. The "Atomic Weight" of an atom, however, is determined not only by the number of electrons and protons but also by the number of neutrons which it contains. Neutrons are electrically neutral particles in the nucleus which contribute only weight, not charge, to the atom. The atoms of an element can, and do, occur in different "isotopes," which differ in mass because their nuclei contain different numbers of neutrons. The element oxygen, for example, is found not only as the most common isotope with Atomic Weight 16, but also with the isotopes whose Atomic Weights are 17 and 18. Therefore, the oxygen nuclei are made of 8 protons, and 8, 9, and 10 neutrons respectively for the three isotopes.

Each element has many isotopes, but only a few are stable; the rest are unstable "radioactive isotopes," which will decay suddenly and spontaneously into more stable configurations. This decay occurs when the atom ejects from its nucleus one or more elementary particles, such as an electron, a positron, or a combination of protons and neutrons known as an "alpha particle." In addition, the decay process is usually accompanied by the emission of a high energy burst of electromagnetic radiation known as a "gamma ray."

Radioactive "Half Life"

Samples of radioactive material which are large enough to be of interest to a chemist usually contain as many as 10^{20} atoms or more. The individual radioactive atoms decay at a random instant, but the radioactivity of the entire collection of atoms decreases with time according to a simple statistical law, at a rate which is specified by the "half life." The half life is a time interval such that of the atoms of the isotope which were present at the beginning only half will remain at the end of the interval; the rest will have decayed radioactively into another element. Each radioactive isotope has its characteristic half life, which may be between 10^{11} seconds and 10^{12} years. For example, Carbon 14 (written C^{14}), a radioactive isotope of carbon with fourteen neutrons in the nucleus, has a half life of 5568 years, and decays into the element nitrogen by converting a neutron into a proton which it keeps and an electron which it ejects. See Fig. 1 for a schematic picture of this process. If one starts with a thimble-full of C^{14} atoms, 5568 years later the thimble will be only half full, since the other half of the C^{14} atoms will have decayed into nitrogen and passed off as a gas. Similarly, during the next 5568 years, half of the remaining C^{14} atoms will decay, leaving the thimble only one-quarter full, and so on.

Radioactive isotopes can be used as tracers because the particles and gamma rays which are emitted when the atoms decay can be detected and counted with proper instruments. The uranium prospector carries such an instrument, often a

Geiger counter, which he uses to detect the gamma rays which uranium and other radioactive elements occurring with it emit as they decay. A radioactive isotope of an element, as explained above, behaves in exactly the same way chemically as the normal isotope, but its presence, even in minute concentrations, can be detected with a Geiger counter the same way that the uranium prospector finds his lode. The tracer atoms are then said to be "tagged." Many of the uses of radioactive tracers for experimentation fall into two classes: tagging specific atoms and measuring concentration.

Tagged atoms, for example, can be substituted for specific atoms in complicated organic compounds, so that the progress of these atoms can be followed with a Geiger counter through chemical and biological processes. For example, a physiologist can give an animal food which contains some radioactive carbon atoms substituted for normal carbon atoms; the radioactive carbon will be used for the animal's life processes just like any other carbon. By measuring the radioactivity later, the scientist can determine where in the body the tagged carbon atoms were deposited. Many wonderful research projects have been done, and will be done, using tagged atoms, particularly in the fields of chemistry, biochemistry, and medicine. For example, much has been learned recently about the structure of protoplasm and of cholorphyll and of the chemical reactions of photosynthesis. Most of these results obtained by the use of radioactive tracers could not have been obtained any other way.

Measuring Concentrations With Tracers

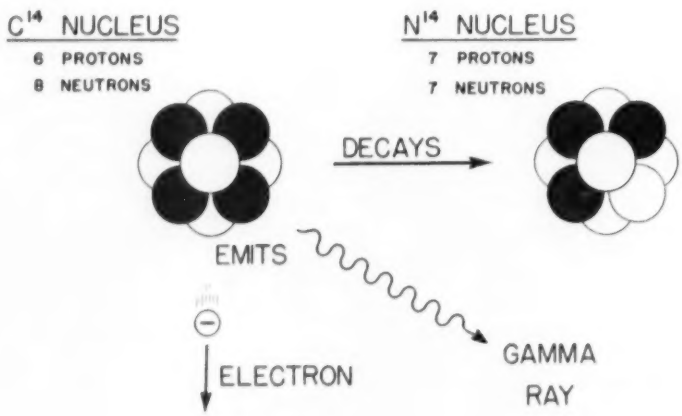
Professor Diamond is using tracers not to tag particular atoms, but simply to measure the concentration of particular chemicals in solution. Quantitative chemistry, which is very highly developed, has methods which could be used to separate these chemicals from the solutions and to determine their abundance. These gravimetric, or weighing, methods are slow and tedious, however, and would take years to perform the experiments which can be done in a week using tracers. In addition, tracers are much more sensitive than other methods, allowing the convenient measurement of concentrations over a much wider range than was previously possible.

Some of the atoms of the substance whose concentration is to be measured are replaced by atoms of a radioactive isotope of the same element. The substance containing the tracer will behave the same way in the chemical processes being investigated, but its chemical concentration can be determined simply by measuring the radioactivity of known quantities of the solutions. The radioactivity is measured by counting the radioactive particles or gamma rays which a sample emits in a known time, by means of a Geiger or scintillation counter.

Professor Diamond is interested only in the relative concentration of the tracer in several samples; this is very much simpler to determine than absolute concentration. The ratio of the concentrations in the samples to be measured is simply the ratio of the number of particles or gamma rays which they emit during equal time intervals. The particles can be detected and counted with a Geiger counter, while for gamma rays a scintillation counter is more convenient. In this work it is much more satisfactory to count the gamma rays than the particles, since the particles are very easily absorbed by intervening matter before they are detected, while gamma rays are much more penetrating.

The scintillation counter which Professor Diamond uses is a specially prepared crystal of sodium iodide encased in a protective aluminum shell, as shown schematically in Fig. 2. There is a well in the top of the crystal in which can be placed little vials containing the samples whose radioactivity is to be measured. Since the crystal is relatively large and dense, there is a good probability that it will absorb most of the gamma rays from the radioactive tracer in the sample. Each absorbed gamma ray causes a tiny speck of visible light in the crystal; hence the term "scintillation." The crystal is cemented onto the face of a sensitive photoelectric cell which "sees" the specks of light and produces corresponding electrical impulses. These impulses, each corresponding to the decay of a radioactive tracer atom, are amplified and counted by electronic circuits. Thus, all that is necessary to measure the radioactivity of a sample is to set the vial into the counter well, zero the instrument, and start it counting. At the end of a precise time interval, the counter is turned off, and the number of gamma rays counted may be read on the neon lights of the instrument. In this way, the relative concentration of many samples may be determined in a few hours. Thus, radioactive tracers are not indispensible for Professor Diamond's work, but they are much faster, more convenient, and more sensitive than traditional gravimetric methods.

(Continued on page 48)



Decay of radioactive carbon fourteen to normal nitrogen.

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BALL BEARINGS

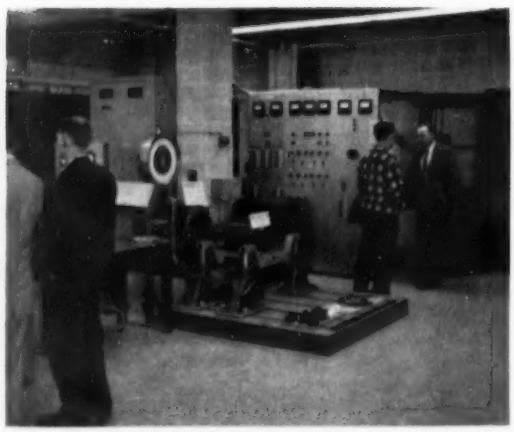
NOTHING ROLLS LIKE A BALL

Engineering Displays at

This year, on March 19 through March 23, Cornell University held its annual Farm and Home Week. This event is sponsored by the New York State College of Agriculture and Home Economics each year to attract large crowds of homemakers and farmers who have been out of school for several years, that they might see and learn about the latest developments and methods for use in homemaking and farming. Among the many exhibits for the farmers are demonstrations of new farm machinery and farm management methods as well as of new crops and methods of cultivation. For the women there are food talks and discussions on well-rounded diets, new fabrics and other recent developments which can help make homemaking easier and better. Although this week is sponsored by the College of Agriculture and Home Economics, most of the work is done by the students and all of the co-ordinating efforts are done by the Ag-Domecon Council.

Even though the events of Farm and Home Week are directed toward the farmer and the homemaker, those not directly connected to farming and homemaking. In the past, exhibits have dealt with everything from conservation to life in India.

In the past, there has been more of a diversity of exhibits; however, during the past year, most of the developmental work was done in improving machinery rather than inventing new machines. Above is shown part of the Agricultural Engineering exhibit of farm power.

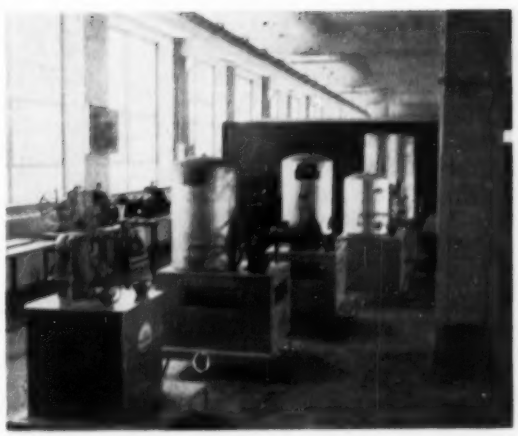


In the picture shown here, a tractor is being tested on a dynamometer. This testing machine is used to demonstrate and determine the power which the motor of the tractor can develop.

t Farm and Home Week

Because the tractor is one of the most important and versatile implements in helping the farmer in his work, the tractor exhibits played a big part in the Farm and Home Week displays. Part of this display is shown here, with one of the many attachments for tractors—a high pressure sprayer—shown in the left foreground.

Among the most interesting exhibits was the display of recent developments in electrification of the farm and the home, shown above. This exhibit was of interest to both homemakers and farmers as it showed the newest changes in electrifying the home as well as the farm.



Pumping equipment is, of course, of great importance to the farmer in much of his work. Here we have an exhibit of some of the latest developments and newest equipment in the pumping line.—everything from pumps for use in the home to pumps which will help make the farm more efficient and easier to run.

YOUR FUTURE—Chemistry and Koppers?

IN an age when most frontiers are shrinking, there is one that is constantly growing—the frontier of the chemist.

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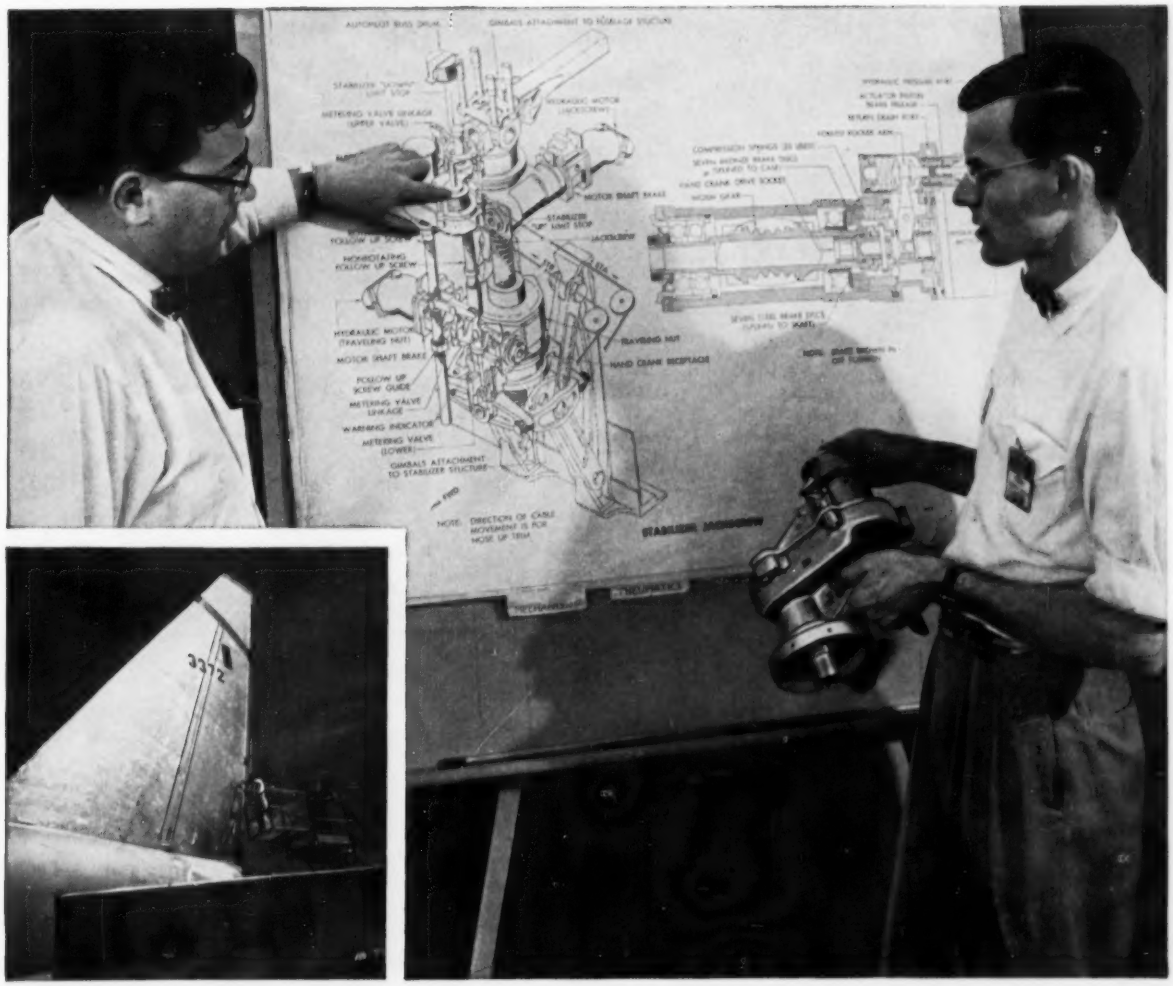

B-52 jack screw—a typical Boeing design challenge

On Boeing B-52 bombers, the horizontal tail surface has more area than the wing of a standard twin-engine airliner. Yet it can be moved in flight, up or down, to trim the aircraft.

The device that performs this function is a jack screw, which, though it weighs only 255 pounds, can exert a force of approximately 225 *tons!*

Many kinds of engineering skills went into designing and developing a jack screw so precise that it automatically compensates for stretch and compression under load. Civil, electrical, mechanical and aeronautical engineers, and mathematicians and physicists — all find challenging work on Boeing design projects for the B-52 global jet bomber, and for the 707 jet tanker-transport, the BOMARC IM-99 pilotless interceptor, and aircraft of the future.

Because of Boeing's steady expansion, there is continuing need for additional engineers. There are more than twice as many engineers with the company now as at the peak of World War II. Because Boeing is an "engineers' company," and promotes from within, these men find unusual opportunities for advancement.

Design engineers at Boeing work with other topnotch engineers in close-knit project teams. They obtain broad experience with outstanding men in many fields, and have full scope for creative expression, professional growth and individual recognition. And they find satisfaction in the high engineering integrity that is a Boeing byword.

In addition to design engineering, there are openings on other Boeing teams in research and production. Engineers like the life in the "just-right" size communities of Seattle and Wichita. They may pursue advanced studies with company assistance in tuition and participate in a most liberal retirement plan. There may be a place for *you* at Boeing-Seattle or Boeing-Wichita.

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Preparing For Leadership

A Challenge to Engineers in a Technical Age

by

RICHARD BRANDENBURG, ME '58

To fill an estimated 50,000 engineering jobs this year, American industry must recruit from among only 23,000 engineering graduates. Swamped by glowing advertising and promises of fantastic starting salaries, the engineering college graduate faces a mad scramble for his services that has resulted in charges of engineer hoarding and ineffective utilization of technical manpower.

Fear of the threat of Russian technical progress, the challenge of obtaining more and better secondary school teachers, the problem of encouraging high school students to prepare themselves for college work in science and engineering, and the need for industry to carefully evaluate the role of the engineer as an individual, have resulted from the race for more scientists and engineers. The race delineates another problem—that of the adequacy of engineering training in the development of the complete man.

Indicative of the growth of technology are figures for the period 1930-1954, showing an increase in the population of the United States of 32%, in the number of engineers of 20% and in the number of scientists of 335%. Yet the need for engineers far exceeds the supply. Industry has therefore sought to ease its technical manpower shortage by making increasing efforts to use technicians and computers to free engineers for more creative thinking. Specialized staff groups, such as the engineering correspondence and specifications division used in the aircraft manufacturing industry, serve to relieve engineers of some of the diverse responsibilities of their jobs.

Industry recognizes the need for fitting the man to the job, and in some cases provides a rotation program to give the newcomer a feeling for various types of projects. Some companies have sought to aid the problem of technical education by loaning their top personnel to colleges as teachers in engineering subjects, providing summer employment for college and high school instructors, establishing scholarship funds, and assisting employees who desire to supplement their jobs with outside courses, or who desire to obtain advanced degrees.

Making a Life Is Important

Yet the emphasis throughout is on quantity. The need for engineers is urgent and critical. But the end result of the quantity emphasis, both in terms of education and in terms of what happens after the student goes to work, may augment the problems of the engineer as an individual. The obsession to fill the quota may obscure the long range need to encourage engineering leadership and professional prestige that are recognized as valuable by society as whole. The challenge that faces the engineering student, as well as the practicing engineer, is one often described as not only that of making a living, but of *making a life.*

To meet that challenge is to recognize the need for engineering students to obtain the greatest possible grounding in the humanities, and in areas of human interrelationships. The challenge of making a life means that throughout his career, the engineer must be sensitive to the diversity and value of the endeavors and thoughts of his fellow men. He must develop, in the words of Dean L. R. Chamberlain of Columbia University, "the capacity for synthesis. . . . The individual or group to whom we must look in this era of crisis will be those who have compounded their capacity for vision and penetration by drawing upon all the resources of wisdom and understanding available to mankind. This is what I mean by men with the capacity for synthesis." Engineers must not scoff at the worth of human values and intellectual concepts beyond the realm of science. Engineers must use their capacity to think clearly by learning to *express themselves* with equal clarity, relating their understanding of technology to the lives of others.

DuPont Pinpoints Need for Leaders

The need for leadership from the ranks of engineers was pinpointed in a speech given a year ago by Henry B. DuPont, Vice President of E. I. DuPont de Nemours and Company. Mr. DuPont asserted that engineers must realize that their obligation to society goes well beyond the narrow limits of their specialty. The problem is twofold—"greater understanding by the engineer of social problems, greater understanding of engineering problems by society generally—that is the goal we should seek." Mr. DuPont emphasized the need for engineers to communicate with the layman. "As creators of technology, it is clearly up to us to see that it is understood. It seems to me that it is part of our responsibility as engineers to step forward and become the voices and champions of technical progress. We must explain; we must teach the real facts; we must become missionaries, so to speak, carrying the message and promise of technology to all people." The

(Continued on page 40)

College News

Thurston Hall Test Bay

—A hangar-sized test chamber on the Cornell campus is giving university engineers a better tool for finding out how structures and materials react to the stresses and strains of actual use.

The unusual facility is designed to act as a huge testing machine, capable of pulling, squeezing, bending and twisting structures as big as a medium-sized house. Its ability to put a structure to three-dimensional tests is said to give it an advantage over conventional testing devices of its range.

Although tests so far have been limited to comparatively simple structures, the chamber can handle full-scale bridge and airplane components and other units of similar size.

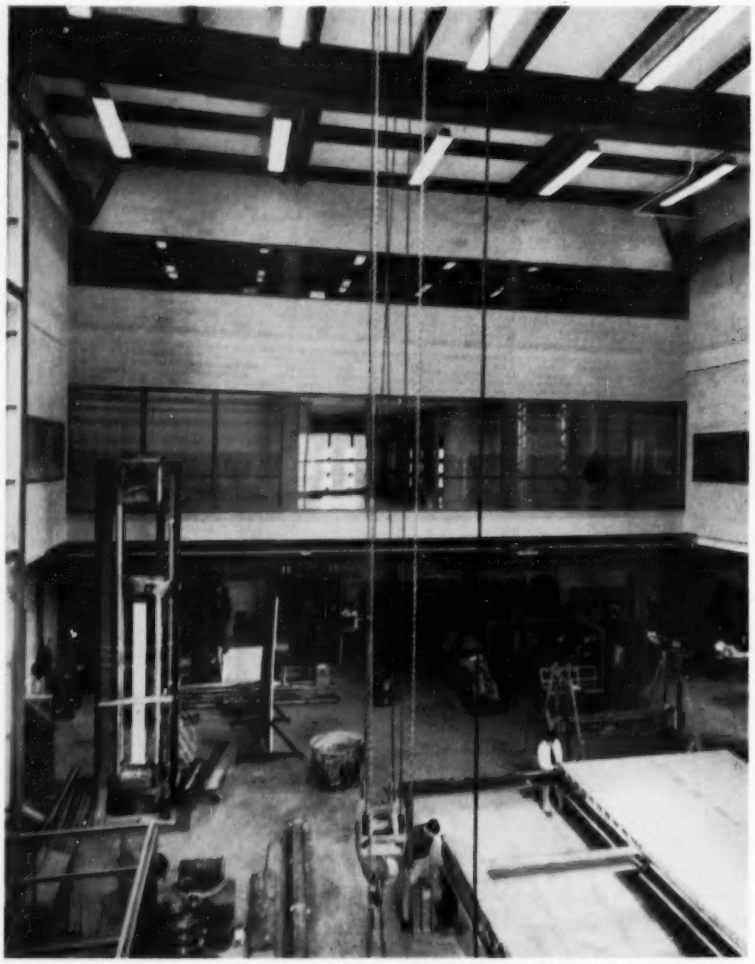
Filling a wing of Thurston Hall, the chamber soars 40 feet from a floor that is 55 by 60 feet in area Forces and loads can be applied from ceiling, floor, and side walls in all sorts of combinations and up to many thousands of pounds. A 40 by 90 feet lowered ceilinged part of the same testing area offers additional space for such work.

The big test bay is the realization of a desire of S. C. Hollister, Cornell's dean of engineering, "to simulate the real performance of engineering structures and devices under the complex conditions of actual use."

Rugged as well as versatile—some have likened it to a torture chamber—the hall is floored with 18 inches of reinforced concrete that can withstand a load of 100,000 pounds per square foot. The center portion of the floor, about 20 feet square, is concrete down to bedrock and can take any conceivable load.

Twenty-seven steel anchors to bedrock can take an upward pull of 200,000 pounds apiece. Steel columns, supporting a crane and the roof, will withstand forces of three quarters of a million pounds each.

Yet to be installed is a box-shaped girder spanning the width of the room and adjustable to any height. This will allow loads to be applied at any number of locations on large structures.



This three-story structure testing bay in Cornell's Thurston Hall can accomodate a structure as big as a house. In three dimensional tests, machines pull, squeeze, bend, and twist objects to find how they will react to actual use.

The test wing has more conventional apparatus too: a 400,000-pound universal testing machine that can test beams up to 40 feet long, a device for testing columns up to 17 feet tall, two movable testing machines of 100,000-pound capacity for use anywhere in the chamber and in any direction, four fatigue-testing units and many special devices designed by the Cornell staff for unusual testing problems.

Thurston Hall, completed in 1953 as part of the university's new engineering quadrangle, is named for Robert H. Thurston, pioneer in engineering education and inventor, who was director of Cornell's Sibley College from 1885 until his death in 1903. It houses the Department of Engineering Mechanics and Materials, headed by Professor D. F. Gunder.

Architects Design Beach

All through the clouds and snow of an Ithaca winter, the 17 city and regional planning students in the College of Architecture have lived

(Continued on page 52)

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C. Edward Murray, Jr.—'14

ALUMNI ENGINEERS

William B. Correll, CE '43 is superintendent of engineering, buildings, and equipment for Miller & Rhoads, Inc., Richmond, Va. department store. He and Mrs. Correll (Rosemary Pew, '44) live in Richmond at 2215 Stuart Avenue.

Seymour W. Ferris, CE '21, section chief, Research and Development Department, Sun Oil Co. is author of "Handbook of Hydrocarbons," published recently by the Academic Press, Inc. of New York City. By means of tables prepared by Ferris, a specific compound can be promptly located in relation to its physical properties and boiling point. The author lives on Rancocas Road, RFD, Mount Holly, N.J.

Thomas E. Davison, ME '13, retired January 1 after serving twenty-seven years with Jersey Central Power & Light Co. in Asbury Park and Interlaken, N.J. as a transmission engineer, a position to which he had been promoted in 1952. A son, **Malcolm, ChemE '55,** is with General Electric Co. in Schenectady, and a daughter, Mary Ellen, also '55, is now teaching in Monroe High School, Rochester. Address: PO Box 786, Bath, N.J.

J. Henry Parker, ME '33, is chief engineer and director of Rath & Strong, Inc. of Boston, Mass., management consultants and industrial engineers. A son, Henry Randall, is a freshman in Mechanical Engineering. Address: Green Mountain Road, Claremont, N.H.

Stanley J. Chute, ME '13, retired the first of the year from M. W. Kellogg Co., engineers and constructors of oil refineries and chemical plants. He had been chief engineer of the heat transfer division for the last 24 years. Stan has been a licensed New York State professional engineer since 1923, and has been one of the pioneers in the development of shell and tube heat exchangers. He lives at 312 Emwood Ave., Ridgewood, N.J.

Bob Fitzner, CE '52, a Dravo engineer, is working on construction of the Mississippi River Bridge at New Orleans. Address: 4400 Perlita, New Orleans, La.

Vincent B. Lamoureaux

Vincent B. Lamoureaux, CE '20, sanitary engineer director, Public Health Service, sailed to Uruguay to become a member of the U.S. Operations Mission there. He will advise on urban and rural sanitary engineering problems as well as instruct university students in public health engineering.

Lamoureaux worked for the Illinois Department of Highways and later for the Department of Public Health. He then moved south and joined the Florida state board of health. He was with TVA in the thirties. Commissioned in the Public Health Service, he became sanitary engineer director in 1949, and filled traveling assignments in Washington, Norfolk, Cincinnati, San Francisco, Denver, and New York City. Recently he was assistant chief, public health division, International Cooperation Administration in Washington.

Address: Health, Welfare & Housing Field Party, USOM of Uruguay, c/o American Embassy, Montevideo, Uruguay.

Justis Rising, ME '13, received the Distinguished Service Award from the Division of Engineering Drawing of the American Society for Engineering Education. This is an annual award made by the ASEE based on the five qualifications: (1) Success as a teacher; (2) Improvement of the tools and conditions for teaching; (3) Improvement of teaching through various activities; (4) Scholarly contribution; and (5) Service to the Division of Engineering Drawing of ASEE. Jud received this award as the result of his outstanding accomplishments along all of these lines at Purdue University since he joined the faculty there in 1923 as head of engineering drawing, a position he held until 1941. This was a period of great increase in enrollment and staff, when many new procedures and methods were introduced; among others, machine-scorable examinations and the production of movies, at first silent, and later with sound track, to help in the teaching of drawing. Jud took a leading and active part in these developments, especially in the production of movies, so that in 1940 he was relieved of administrative work in the drawing department, to allow him to spend full time preparing aids for use in war training. He held a commission as first lieutenant in the Ordnance Reserve Corps.

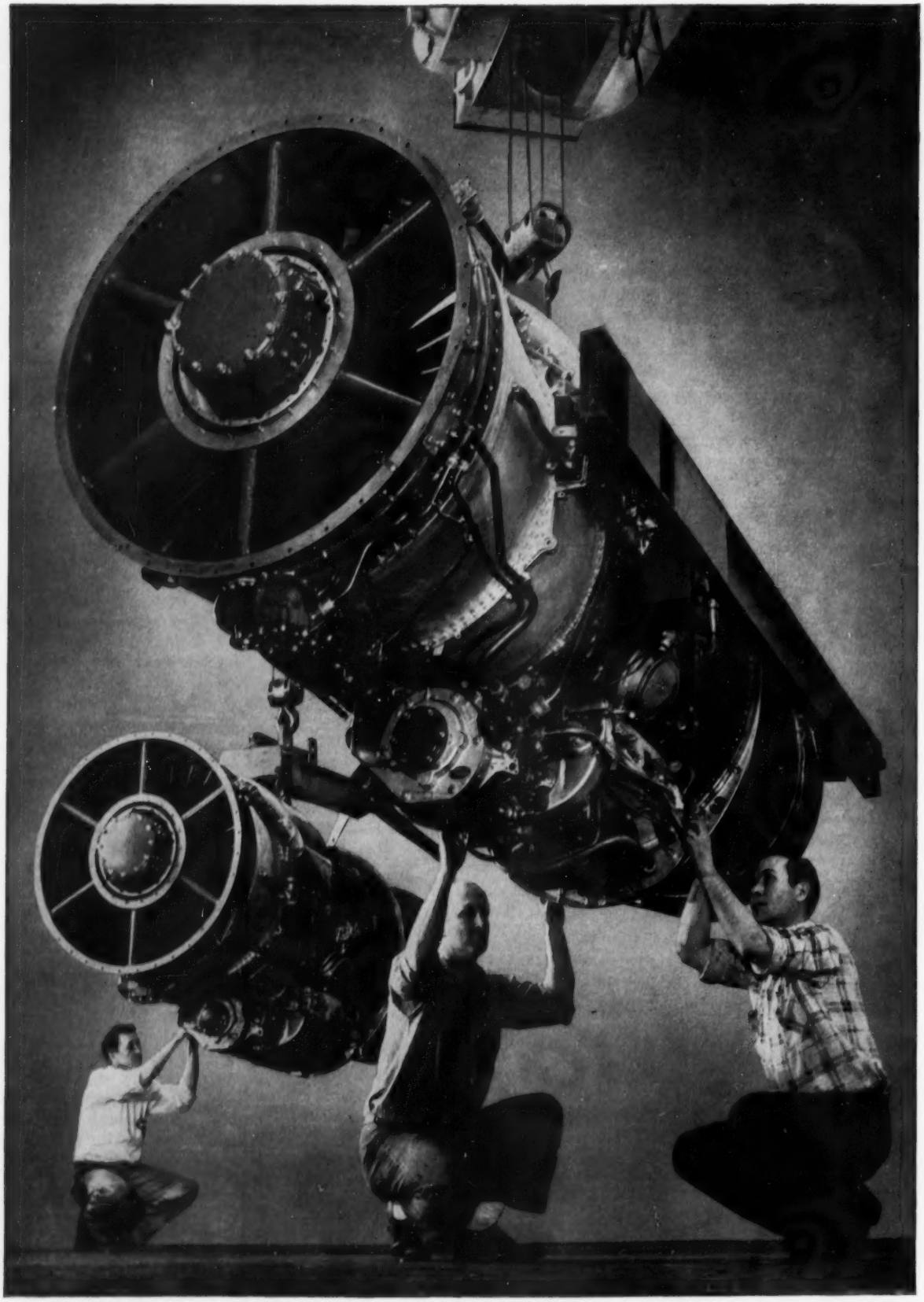
After Jud graduated from Cornell, he worked for Ingersoll-Rand and Corning Glass Works. In 1919 he became an instructor in engineering drawing at Michigan State College; then, four years later, went to Purdue. Jud has been closely connected with the ASEE since 1929 and is presently a member of their national teaching aids committee as well as their policy committee.

Robert A. Sharood, CE '27, is a consultant with Coverdale & Colpitts on the rehabilitation of the Pacific Railway in Mexico. His address is c/o Pacific Railway, Guadalajara, Jal., Mexico.

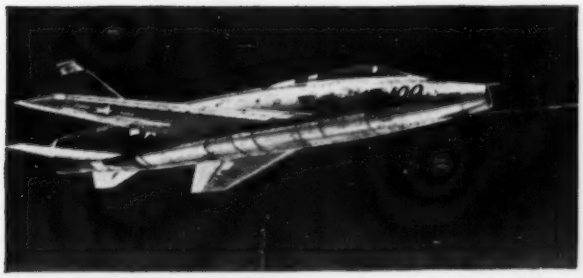
Herbert F. Cox, Jr., ME '33, is an industrial consultant and does "consulting work in general lines of product design and manufacture. If there is a specialty, it is in the design and re-design of equipment and packaging for the dairy industry." Address: 406 Sedgwick Drive, Syracuse 3.

Eugene R. Smoley, EE '19, vice-president of Lummus Co. of New York is serving as assistant chairman of the national program committee of the American Institute of Chemical Engineers.

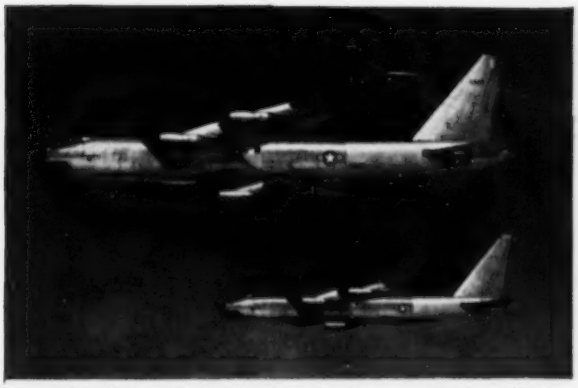
(Continued on page 34)



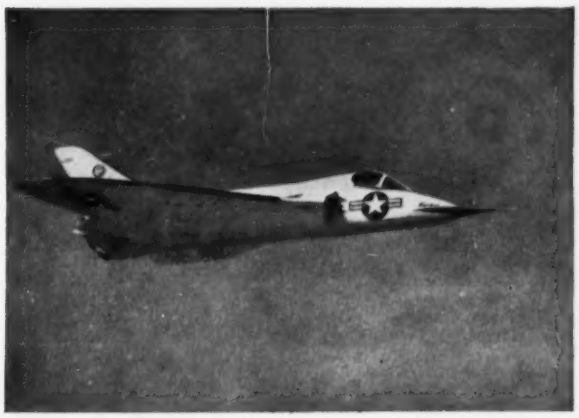
The J-57, in the 10,000-pound thrust class, is the most powerful turbojet engine now in production. A new generation of U.S. air power has been designed around this mighty new Pratt & Whitney Aircraft engine.



North American's F-100 Super Sabre, fastest Air Force jet fighter, is powered by Pratt & Whitney Aircraft's J-57 engine.



First all-jet heavy U. S. Air Force bombers are the huge Boeing B-52s, powered by eight J-57s mounted in pairs.



The Douglas F4D Skyray, fastest Navy jet fighter, will be powered with the big J-57 engine.

The Douglas A3D, the Navy's most powerful carrier-based attack airplane, has two J-57 engines.

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The importance of the J-57 in America's air power program is clearly shown by the fact that it is the power plant for three of the new "century series" fighters for the U. S. Air Force—North American's F-100, McDonnell's F-101 and Convair's F-102—as well as Boeing's B-52 heavy bomber. The Navy, too, has chosen the J-57 for its most powerful attack aircraft, the Douglas A3D, the Douglas F4D fighter and for the Chance Vought F8U day fighter. And the J-57 will power the Boeing 707 jet transport.

The J-57 is fully justifying the long years and intensive effort required for its development, providing pace-setting performance for a new generation of American aircraft.

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Smog

(Continued from page 11)

ing the heavy dust particles to be thrown against the cylinder wall and then drawn into a hopper. Unfortunately this device is effective in cases involving only large particles.

Another machine which has been effective in reducing pollutants in the air is an electrical precipitator. This device employs the principle of attraction of opposite electric charges. The particles in the polluted exhaust stream are charged in a high voltage electric field and are then attracted to a plate of opposite charge where they are collected. When the plate is shaken or "rapped" the pollutants drop into a hopper.

A third control device is operated on a principle similar to the home vacuum cleaner. Particles in the polluted air stream drawn into the device impinge upon a filter medium of cloth or fibre glass construction. The accumulation of solid particles itself on the inside of the filter medium forms a matrix which increases the effectiveness of the device. These collectors take several forms. The most famous of these in the industry is known as the "baghouse" which actually is a structure containing a large number of vacuum cleaner type bags. These bags are automatically or manually shaken. The collected pollutants which otherwise might have gone into the air are dumped into hoppers and carried away.

Another type of device for the removal of contaminants in the air is a wet collector or "scrubber." These devices, as the name implies, actually take contaminated exhaust gases created in an industrial process and scrub them by the vigorous agitation of water. Scrubbers may capture the particles by striking them at high velocities with droplets of water, or the particles may absorb moisture, become heavier, and settle out more rapidly, or they may be caught upon the wet surfaces of the scrubber and be washed down.

A major problem with which researchers are faced is the elimination of auto-exhaust pollution. Automobiles, leaving a large portion of their fuel unburned, are constantly spewing dangerous hydrocarbons into the already polluted air. Many devices to control this important source of pollution have been suggested and are presently being tested, but as yet none have been put into practical use.

Methods of Controlling Smog

The scientific methods used to control smog have met with some measure of success. Governments too are attempting to control smog in their own way. In Los Angeles there is an elaborate permit system in operation which controls the number of new air polluting industries which can be established. Methods are even in use to prevent citizens from burning trash on smoggy days.

American cities like Pittsburgh and St. Louis have spent millions of dollars to control their smog problems. Los Angeles is now spending untold amounts of money to rid itself of the nuisance. The reason for this concern is quite simple. Numerous surveys and scientific reports have shown that smog is a serious menace to health. Then too, while it is present it produces annoying eye, nose, and throat irritation. Smog also damages vegetation. Lastly, smog reduces visibility to a dangerously low distance.

Too many of us regard Los Angeles' battle against smog as well as the battles of several other cities against the problem as being the concern of those cities alone. We must realize that the same type of smog that has blanketed these cities could, under the proper conditions, blanket our own communities. By learning from the actions of the unfortunate victims of the smog menace, we can prevent similar conditions from occurring in our towns.

SOURCES

National Municipal Review, December, 1955.

Public Information and Education Division, Los Angeles, Cal.

Bureau of Smoke Control, County of Allegheny, Pittsburgh, Pa.

Air Pollution Foundation, Los Angeles, Cal.

Alumni Engineers

(Continued from page 31)

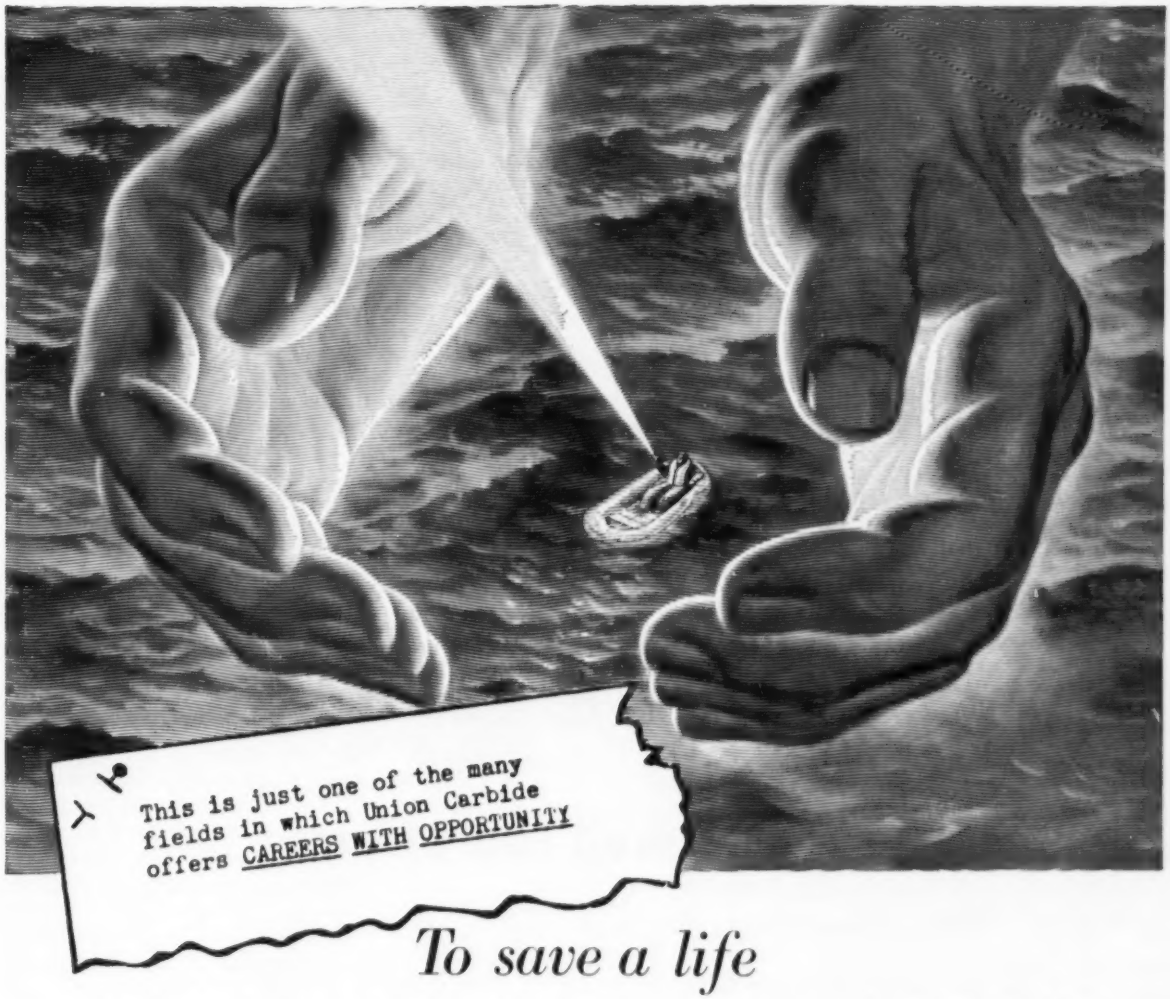
Andrew S. Gill, Jr.

Andrew S. Gill, Jr., ME '43 has been named manager of the central research division of Eaton Manufacturing Co., with headquarters in Cleveland, Ohio. He joined the company after leaving military service in 1946 and has been assistant manager of research at the central research division since last August. Prior to that he was the division's chief experimental engineer. He resides with his wife and two sons in South Euclid, Ohio.

David E. Conklin, '50 is a research engineer with Northrop Aircraft. He lives at 3233 Hollypark Drive, Inglewood, Cal.

C. W. Floyd Coffin, ME '12, is executive vice-president of Franklin Railway Supply Co., New York City, chairman of the board of Palisade Trust Co. in Englewood, a member of the advisory committee of the Chase Manhattan Bank, and a director of Combustion Engineering, Inc. In addition, he is vice-president of the North Bergen County Council and a member of the executive board, Region 2, of the Boy Scouts of America. He lives at 284 East Palisade Ave., Englewood, N.J.

Julius F. Siegel, EE '30, president and general manager of General Coil Products Corp., Mineola, has been elected president of American Coil, Inc. and director of Rectifier Corp. in Puerto Rico. A daughter, Sheila, is a sophomore in the College of Home Economics. Address: Cloverfield Road South, Valley Stream, L.I.



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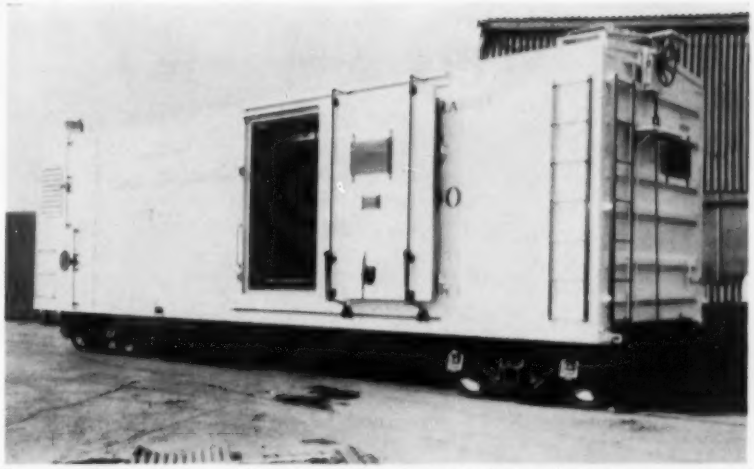
Technibriefs

Frozen Foods for the Arabian Desert

It is now possible for a person in the middle of the Arabian Desert to open a box of frozen strawberries at 0°F and allow it to thaw in the 125°F ambient heat, timing it so that he has chilled fruit for his eating enjoyment. Transporting frozen foods of all kinds across the hot sands is now accomplished with perfect safety as two prototype railroad refrigerator cars have proved during initial tests conducted by the Arabian American Oil Co. The refrigerator cars were manufactured for use on the Saudi Government Railroad which connects the Port of Damman on the Persian Gulf with the capital city of Riyadh, a distance of approximately 360 miles. This railway line, with stations near the Arabian American Oil Company's major oil producing centers, will thus provide increasing quantities of frozen foods to the area.

The railroad cars are the first in the world to be equipped with two separate two-stage low temperature refrigeration compressors. It had been determined that two-stage compressors would be required because of the extremely high ambient temperatures (125°F) prevailing throughout Arabia during most of the year and, consequently, excessive compression ratios would have been encountered had the usual domestic practice using single stage units been followed.

The cars themselves are steel framed, steel sheathed, wood lined, and fully insulated. The roofs of the cars are constructed of aluminum sheets to deflect heat. Each side has a six foot wide, sliding, flush type refrigerator door with screw type door mechanisms to seal the cargo space. This cargo space is approximately 2000 cu. ft. and will transport a load limit of 80,000 pounds of food. Heavy duty roller bearings reduce the possibility of hot boxes and accompanying delays. Fifty ton nominal capacity trucks of stabilized design, rubber draft gears, and rotary type E couplers give the loading a smoother ride.



This recently developed refrigerator can can maintain frozen food at a temperature of 0°F for the duration of a 350 mile trip at outside temperature of 125°F.

To minimize heat transfer, the new reefers are insulated with aluminum sheets and 8 inches of fiberglass on the floor, sides, and ends. Ceiling contains 10 inches of this type of insulation. The exterior of the cars are painted chalk white to reflect heat away from the surfaces. An overall view of one of the cars is shown, with the left end of the car containing the necessary operating machinery and air inlet grills.

Mechanical equipment for each car consists of two separate refrigerating systems each rated at 50% of system capacity to provide protection against refrigeration failure and resultant loss of perishable cargo. Each car includes an air-cooled diesel electric generator with two 150 gallon fuel tanks slung under the frame, two 7½ hp motors, two Freon-12 compressors, two evaporators with automatic defrost mechanism, two air-cooled condensers and all dust tight safety and operating controls.

Tape Recording of Color TV Now Possible

Color television programs can now be recorded on magnetic tape and rebroadcast over standard commercial broadcast facilities, with up to 15 minutes of programming stored on a single 20-inch reel of tape. Full engineering details of the television tape recorder were disclosed for the first time at a special session devoted entirely to discussion of the system by Dr. Harry F. Olson and five members of the development team at Radio Corporation of America's David Sarnoff Research Center, Princeton, N. J.

Their reports told of improvements which have been made in the system since its first demonstration in December, 1953, and included these points:

—Programs recorded on the magnetic tape can be erased, and the tape re-used at least 100 times without perceptible deterioration;

—Tape recorded programs can be stored for months with no loss in quality;

—An ingenious system has been designed to regulate tape speed automatically during playback with extreme precision—on the order of one-50 millionth of an inch per second—to eliminate irregularities which might cause the television picture to jump perceptibly on the viewing screen;

—System employs seven different tracks in the half-inch width of the magnetic tape to carry six different types of information. These record the separate electrical signals for the red, green, and blue portions of the color television picture, the high-frequency components of the color signals, and a synchronizing signal to ensure proper relationship among the various elements of the transmitted picture.

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PLASTIC-COATED DUPLEX WIRE is used in this type of electric blasting cap assembly. The insulation has to be particularly tough since the wire assembly is used to lower charges of explosives into blast holes 100 feet or more in depth. The plastic coating on these wires is Hercules Hercocel® E, providing excellent insulating properties, good flexibility, and other physical characteristics to meet rugged field requirements.

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This advertisement appears in BUSINESS WEEK, CHEMICAL WEEK, CHEMICAL & ENGINEERING NEWS, OIL, PAINT & DRUG REPORTER, WALL STREET JOURNAL, JOURNAL OF COMMERCE, *and* NAVAL STORES REVIEW.

Preparing For Leadership

(Continued on page 37)

need for realistic thinking about technology, in the field of economics, and social science, can be met only if "engineers will become more vocal and more articulate in telling the story of technical achievements."

The five year engineering program at Cornell is in part an answer to the need for leadership from among engineers. The program was originated not only to meet the growing technical requirements of the profession through more thorough preparation in basic science and more comprehensive training in applied engineering, but to provide more time for non-technical course work as well. The three-two program adopted by a number of schools, providing three years of liberal arts preparation for two years of engineering is another approach to the problem of providing a liberal background for engineers. Educationally the problem concerns high schools too. As they encourage students to take preparatory work in math and science that will enable the student to study engineering in college, they must carefully prepare that student in the fundamentals of good writing and speaking, as well as make him aware of the great bodies of truth beyond the discipline of science.

Problem Challenges Individuals

The greatest challenge to develop leadership in engineers lies with the individual student—and the individual professional engineer. No college degree, whether in liberal arts or engineering, makes an educated man. Rather it is what the individual recognizes as significant in his life, what the individual does with his curiosity, and what the individual establishes as goals and beliefs, that mark him as an educated man. Engineering students who take time to read, work, and express themselves in areas outside their classrooms are moving in the direction of a broader, more effective education. Practicing engineers who take time to participate in community, government, and church affairs, to speak and write for an audience other than just engineers are likewise moving toward the goal of understanding themselves, their fellow men, and the purpose for living. In this way both students and practicing engineers can help offset the mania for engineering quantity by encouraging engineering quality that is not only technically competent but able to contribute effective leadership in a variety of human endeavors.

In a personal sense, the capacity for synthesis that results from combining the liberal with the technical perspective provides individual satisfaction and direction in living. The engineer can thus find a life that is complete. In the words of Louis Bromfield, "The *complete* man is a happy man, even in misery and tragedy, because he has always an inner awareness that he has lived a complete existance . . . in success and failure; in satisfaction and disappointment; in distinction and vulgarity. Not only is he complete; he is much more; he *is* a man."

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The textile industry—through its variety of processes and products—plays one of the most significant roles in the everyday lives and activities of all Americans. Today, efficient men, methods and machines produce yarns and fabrics for an almost endless list of products of which clothing, carpets, drapes, tires, belting, shoes and furniture are but a sample. With heartening regularity, textile manufacturing advances are being made, new fibers and blends created, and new applications developed.

Pacing textile industry progress is an intensive research program. Synthetics now are as familiar and serviceable as cotton, wool and other natural fibers, and have freed us from any dependence upon imports such as silk. Concentrated development of the industry's manufacturing processes has brought new techniques and methods to improve and speed up the transformation of raw fiber into finished material.

But not content with the dynamic progress already made, the textile industry is continuing to reinvest earnings to insure further advances. It is enlisted—with its suppliers and processors—in a never-ending effort to improve machines and methods.

An important requirement in this second largest industry in America is steam, used in textile plants for power, processing and heating. The Babcock & Wilcox Company, whose experience with steam extends over nearly a century, has long been a contributor to textile industry progress. B&W boilers and associated equipment are being improved constantly as B&W's research and engineering facilities devote time, effort and money to help make better boilers for all industry. The Babcock & Wilcox Company, Boiler Division, 161 East 42nd Street, New York 17, N. Y.

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This is your year of decision. We invite you to look into Pittsburgh Plate Glass Company. To help you become better acquainted with PPG, we suggest you get a copy right away of the booklet entitled, "Toward New Horizons with Pittsburgh Plate." Ask your placement officer for a copy or write directly to the Pittsburgh Plate Glass Company, General Personnel Director, One Gateway Center, Pittsburgh 22, Pennsylvania.

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THIS COMMUNITY CENTER in a Dow city is typical of the excellent recreational facilities available to Ralph Pfister and other Dow employees.

Thus, this 27-year-old production engineer explains his new position as Superintendent of a multimillion dollar warehouse with a work force of 100 men.

In June, 1951, Ralph Pfister graduated from Northwestern University's Technological Institute. His studies, experience and natural inclination pointed to a future in production engineering. Pointed right to a position as process engineer in the Dow saran plant.

Within three years, Ralph moved to Ass't. Superintendent of a production train in a wing of the Styron® plant, to Ass't. Superintendent of the entire wing and two months ago to Superintendent of the 500,000 sq. ft. warehouse serving all wings of the plant.

"Always something new to learn . . . upper management not only allows but encourages our making the important decisions . . . the people are interesting, stimulating both at work and socially."

These excerpts from a conversation with Ralph Pfister give a quick profile of employment at Dow. Here is the fastest-growing company in the nation's fastest-growing industry. Dow communities provide some of America's most pleasant living surroundings and educational and recreational facilities.

Whether your interest be production, research or technical sales, for more information on a career at Dow write for the 16-page booklet "Opportunities with The Dow Chemical Company." Address your request to Technical Employment Department, THE DOW CHEMICAL COMPANY, *Midland, Michigan, or Freeport, Texas.*

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BOOK REVIEWS:

Principles of Chemical Engineering Thermodynamics by Wilson & Ries, McGraw Hill, 1956.

Reviewed by Robert Von Berg, Professor of Chemical Engineering.

In writing a book on thermodynamics for the undergraduate student, there is little or no possibility of providing new and enlightening theories and concepts. Your aim must be to present the basic principles which are rather nebulous generalities and few in number in a way as to make them interesting reading. Once these principles are assimilated, the reader must then be shown how they can be applied to situations in the engineering world about him. The authors have handled these requirements of an elementary thermodynamics text admirably. The book is written for a junior level course in chemical engineering thermodynamics and is considerably less advanced than texts by Dodge and Hougen and Watson, which are intended for graduate level work as well.

If the book is judged on the basis of the requirements of a text for a course in chemical engineering thermodynamics at Cornell, it is lacking mainly in adequate coverage of a number of topics. For the same type course in a four-year program, I feel the material coverage is very nearly right. The concept of available energy is only briefly considered. In a world where high efficiency is becoming so very important, I feel this concept should be given much more emphasis. One of the ultimate aims in learning thermodynamics methods is to be able to make predictions of chemical equilibrium and in turn, use this in rate calculations and reactor design. As in many texts, equilibrium receives too brief a treatment. It is often necessary to make use of empirical methods for calculation of enthalpy, entropy and other thermodynamic properties. Although such methods are discussed quite adequately in the general literature, inclusion of more of this material would have made the book a more valuable reference.

On the other hand, the authors have included material not found in similar texts which should make the book well worth keeping on your reference shelf. The compressibility charts of Nelson and Obert which are plotted using reduced volume as a parometer have been reproduced. These charts overcome the usual trial and error difficulty of standard charts. There is an excellent discussion of graphical pre-

(Continued next page)

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Book Review

(Continued from page 43)

sentation and interpretation that would be helpful to any engineer. The Gibbs-Duhem relations and methods of checking phase equilibrium data consistency is very well done.

The authors have attempted to build a whole series of problems around a single chemical plant flow sheet. The thought is that this will stimulate more interest if each problem has an apparent practical application. The idea is excellent but it remains to be seen whether a great enough variety of problems are possible. They have given only limited coverage to applications in the text. Steam power production, gas compression and refrigeration are the only processes discussed. I am much in favor of this. It demonstrates enough applications but keeps the balance on the side of basic principles rather than application.

Mechanism

Reviewed by Professor H. A. Mabie, Department of Machine Design

The book "Mechanism" by Joseph Stiles Beggs published in 1955 by McGraw-Hill is an interesting book and the first book to be published recently for advanced work in kinematics and mechanisms.

This book is the first volume in the new *Series in Mechanical Engineering* offered by McGraw-Hill and "provides an advanced text on mechanism and also provides the practicing design engineer with a reference book for the analysis of mechanism and a source of mechanical movements."

Two unusual chapters are *Computing Mechanisms* and *The Control of Mechanisms*. The author deals with optical and electrical systems as well as with mechanical systems.

The chapter on gears covers work not usually found in a mechanism text, e.g. analytical treatment of conjugate gears, non-circular spur gears such as elliptical or logarithmic spiral gears, and a mathematical treatment of the cutting of hypoid gears. One subject that is definitely lacking in the treatment of gearing is that of non-standard spur gears (extended center distance system and long and short addendum system).

Mr. Beggs' treatment of cams follows the usual pattern of graphical cam design. He introduces the subject of analytical cam design but does not go far enough with it to make it useful.

The last chapter in the book, *Newtonian Mechanics of Rigid Bodies*, is a very valuable addition and serves as a good reference work on the principles of kinematics and dynamics.

In conclusion it might be mentioned that there are no problems included in the book for class use. This, together with the unusual selection of subject matter, makes the book more useful as a reference book than as a text in advanced mechanisms.

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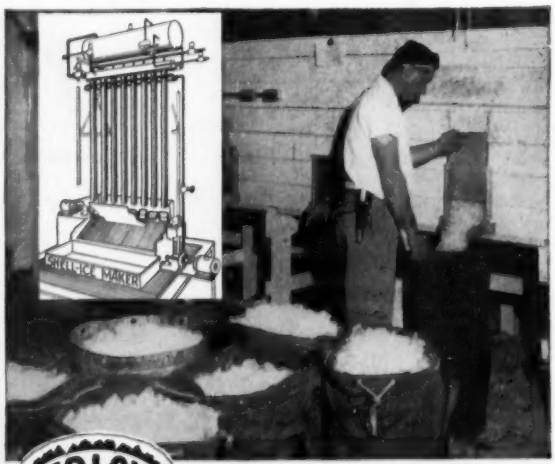

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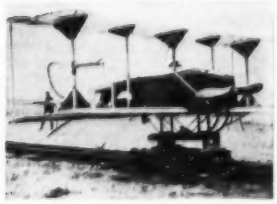

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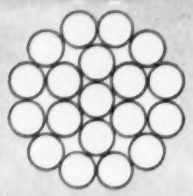

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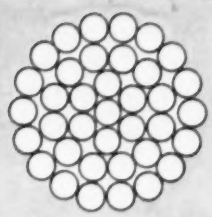

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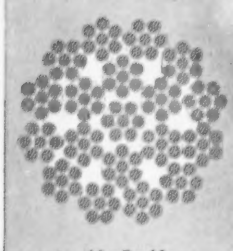

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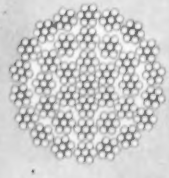

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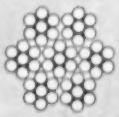

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The Importance of Electrical Conductors

In the ability to transmit electricity, all forms of matter may be divided into two general classes, namely, conductors and insulators. Conductors permit electric current to flow readily; that is, they offer little resistance to its flow, whereas, insulators offer relatively great resistance to the flow of electricity. All substances at normal temperatures offer some resistance to the flow of electric current. In general, the metals are good conductors, while glass, oil and most organic substances are classed as insulators. Although silver offers the lowest resistance to the flow of electricity of the common metals, its cost is such that it is not widely used as a conductor. The conductors most generally used in the cable industry are made of copper or aluminum.

The manner in which electricity flows through elementary material may be readily visualized from the modern concepts of the structure of matter. According to these concepts all elements are made up of minute indivisible particles called atoms. These in turn are composed of a positively charged nucleus around which one or more very small negatively charged particles, called electrons, rotate at high velocity. In conductors, some of these electrons are free to move when only a small difference of potential is applied to the ends of the conductor and, since they are negatively charged, they flow to the positively charged end. This movement of electrons is electric current.

In passing through conductors, *the electrons must pass through the electron fields of many atoms. They thus collide with the atomic nuclei and other electrons. These collisions obstruct the flow of electrons and result in electrical resistance.*

The resistance of a homogeneous conductor of uniform cross-sectional area varies directly as its length and inversely as its cross-section, the length being in the direction of current flow. That is, $R = \rho L/A$ where, R is the resistance in ohms, L is the length in the direction of current flow, A is the area perpendicular to the length and ρ is a constant of the particular material known as its specific resistivity. When the length and area are expressed in the same units such as L = one inch and A = one square inch, $R = \rho \times 1/1$ or $R = \rho$, the specific resistance of the material in ohms per inch cube.

The length and area of a conductor are generally expressed in other units

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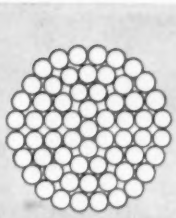

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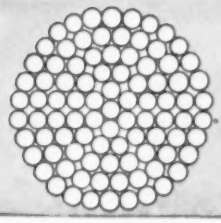

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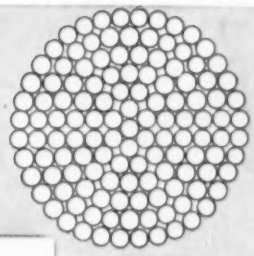

127 strand Concentric Stranding

than inches. The most commonly used unit of cross-sectional area in the cable industry is the circular mil, usually designated as cir. mil or CM. This is the area of a circle whose diameter is one mil, 0.001 inch. The area of a circular mil is $\pi/4$ or 0.7854 of a square mil. The unit of length usually associated with this unit is the foot and the resistance becomes ohms per CM-foot. The resistance of annealed copper and aluminum per circular mil-foot at 20C are 10.371 and 17.011 ohms respectively. The resistance of a copper conductor 64 mils in diameter and one foot long thus becomes $10.371 \div 64^2$ or 0.00253 ohms.

The sizes of electrical conductors *are expressed in the United States in terms of the American Wire Gauge. This was originally set up on the basis of a geometrical progression of 39 steps or sizes between a wire 460 mils in diameter (Size 4/0) and a wire 5 mils in diameter (Size 36). The ratio of the diameter of a wire to that of the next larger size in this series is* $\sqrt[39]{460/5} = 1.12293$. *This ratio has since been used to extend the American Wire Gauge (AWG) to sizes smaller than 36 AWG (5 mils). The sizes of conductors larger than 4/0 are expressed in circular mil area. The size of a conductor made up of a number of wires is determined from the sum of the circular mil areas of the individual wires.*

When current flows through a conductor there is, according to Ohm's law, a voltage drop of $E = IR$, where E is in volts, I is in amperes and R is in ohms, and power equal to EI watts is converted to heat. Since $E = IR$, this power converted to heat becomes I^2R watts.

These two factors, voltage drop and conductor heating, are of prime importance in the design of conductors. Conductors must be of sufficiently low resistance that the voltage drop does not become excessive. In good design this voltage drop should not exceed 3 per cent for power circuits or 1 per cent for lighting circuits. The conductors should also be large enough that, when carrying their current, their temperature does not exceed that for which their insulation is designed. This rated current is referred to as the current carrying capacity. The current carrying capacities of the various sizes of conductors and installation conditions have been established. It should be noted that the temperature attained by a conductor depends not only on the amount of heat generated but also on the thermal resistance of its surroundings.

In addition to providing satisfactory voltage drop and current carrying capacity, conductors must be designed to provide adequate flexibility during installation and service. This is accomplished by building up the conductor from one or more adequately small wires, depending on the flexibility required. For example, the conductor for heater cord or welding cable, which is subject to repeated flexing in service, is usually made up of copper strands having a diameter of .005" or .0063", while the conductor for overhead weatherproof cable may be a single wire.

For reprints of these pages write to United States Rubber, Electrical Wire & Cable Department, Rockefeller Center, New York 20, N. Y.

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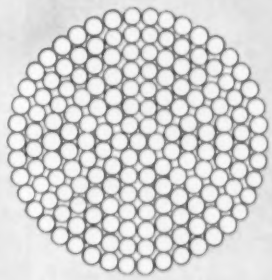

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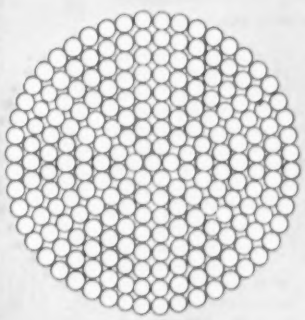

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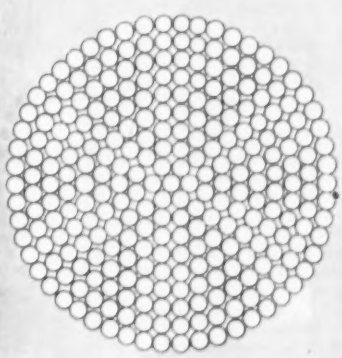

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Radio Chemical Research

(Continued from page 18)

Solvent Extraction Problems

Of the three problems which interest him, Professor Diamond has chosen to attack solvent extraction first. Solvent extraction, also known as liquid-liquid extraction, involves the distribution of a dissolved substance between two liquid solvents which are in contact but which are insoluble in each other. The simplest example is an experiment performed in freshman chemistry laboratory, in which one starts with bromine dissolved in water, and then adds carbon tetrachloride. The carbon tetrachloride is insoluble in water and merely floats on top of it. The bromine is found to pass quickly and almost completely from the water up into the carbon tetrachloride, since its solubility in the latter solvent is very much higher than in water. Most ionic substances originally in the water along with the bromine would dissolve little or not at all in the carbon tetrachloride, and the bromine would have been separated from them. This selective separation, called "extraction," of the bromine from the water, is the valuable feature of solvent extraction. If some undesired substances extract slightly along with the desired species, the process can be repeated over and over until the desired substance is completely isolated. Many other pairs of very dissimilar liquids besides water-carbon tetrachloride exhibit this extraction behavior, each pair having its own favorite substances to extract.

The extraction of halogens by carbon tetrachloride is a particularly simple and well understood process, which can be explained merely by the relative solubilities in the two liquids. Professor Diamond is investigating another and much more mysterious type of solvent extraction, of metallic ions from certain acid solutions into certain organic solvents. The experimental procedure is simple in principle. The metallic ion to be extracted is made a radioactive tracer. It is added in measured proportions to the two solvents, and the mixture is shaken up and then allowed to

The tracers to be used in the experiments must be prepared behind lead bricks since the primary radioactive sources are "very" hot.

settle. When the two immiscible liquid solvents have separated again, a small measured sample of each is measured into the little vials. The two vials are tested for level of radioactivity in the scintillation counter, determining the relative concentrations of the metallic ion in the two solutions. This concentration ratio, known as the "Distribution Ratio," tells how well that ion is extracted by that solvent under those conditions. This procedure is ideally suited to performing large numbers of such experiments at once, varying the solvents, the acidity level, the initial ion concentration, and the temperature to determine the effect of each upon the Distribution Ratio. From the data which has been gathered so far, Professor Diamond has been able to find tentative answers to some of the perplexing aspects of these extractions, although the central question of exactly why the ions extract at all is still unanswered.

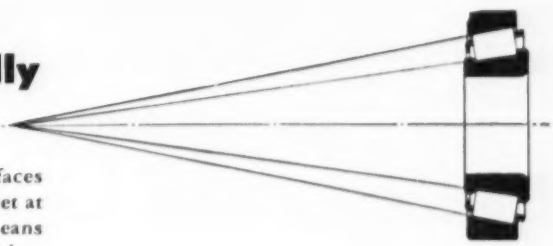
We have discussed the solvent extraction experiments in detail, as they show clearly how radioactive isotopes are being used to speed the measurements. Although the other two problems, ion exchange resins and complex ion formation, differ considerably in chemistry from solvent extraction, the application of tracers to their investigation is very similar.

Another page for **YOUR BEARING NOTEBOOK**

How to get longer roller and belt life in a conveyor system

Engineers had to find a way to reduce costly friction and wear on rollers and idlers in designing this big conveyor system. It handles up to 3,300 tons of ore per hour on each of two 54″ belts traveling at more than 500 feet per minute. Their solution: Mounting the idlers on Timken® tapered roller bearings. Result: reduced friction, less sliding and scuffing between idlers and belts, longer roller and belt life.

True rolling motion, high precision practically eliminate friction



All lines drawn coincident with the working surfaces of the rollers and races of Timken bearings meet at a common point on the bearing axis. This means Timken bearings are designed by geometrical law to have true rolling motion. And they're manufactured with great accuracy to live up to their design. Result: Timken bearings practically eliminate friction, give longer bearing life, keep conveyors rolling smoothly.

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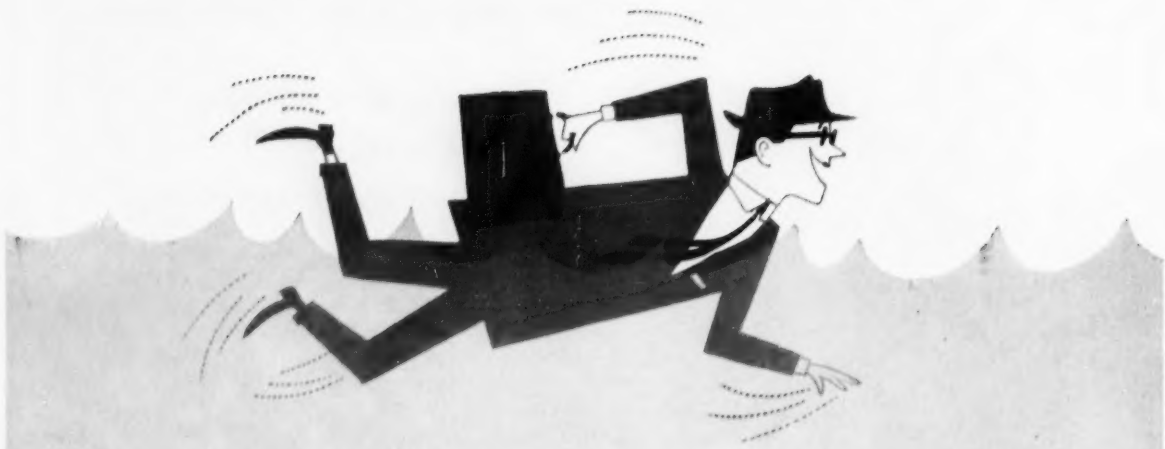

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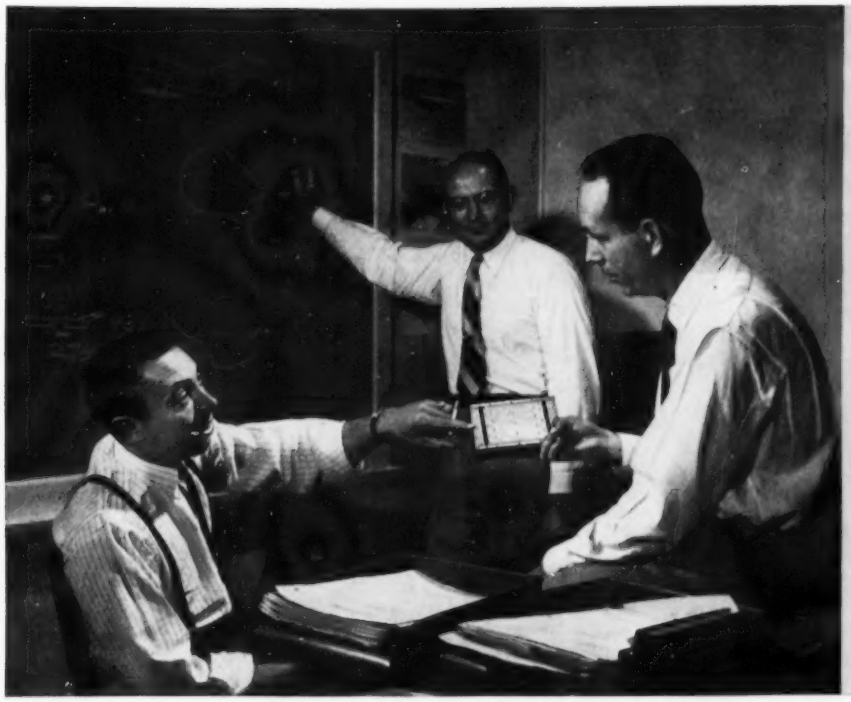

Research Specialist Edward Lovick (right) discusses application of experimental slot antenna in the vertical stabilizer of a high-speed aircraft with Electronics Research Engineer Irving Alne and Electronics Research Engineer Fred R. Zboril.

Lockheed antenna program offers wide range of assignments

Airborne Antenna Design is one of the fastest-growing areas of endeavor at Lockheed. Advanced development projects include work on stub, slot, reflector-type, horn and various dipole antennas.

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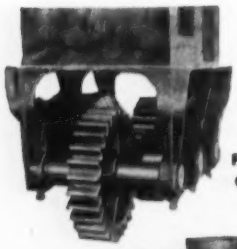

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College News

(Continued from page 28)

in imagination on Hawaii's Waikiki Beach, where the temperature stays between 60 and 85 and sunshine is common. Their project has been to redesign the beach to accommodate twice as many tourists without causing congestion. Professor Frederick W. Edmondson thought up the project as the result of a trip to Hawaii last year, where he learned of a ten-year plan to boost the number of tourists from 100,000 to 280,000 a year.

After hearing a summary of the situation by Professor Edmondson, who brought back dozens of photographs of the present day beach, the students formed study groups which reported the necessary economic, geologic, governmental, and historical data. Redividing, groups of students tackled the various redevelopment problems—traffic, recreational areas, land use, utilities, construction problems, and financing.

The traffic committee brought forward the following suggestions: the construction of a highway north of Waikiki to carry through traffic around the beach area; a new bridge across the Ala Wai Canal, replacing two present bridges and connecting with the thruway by a cloverleaf; curving streets to service the beach area only; overpasses to allow bathers to reach the beaches without crossing traffic, as they now must; and a number of multi-story garages to solve parking congestion.

As another example, consider the finance group's recommendations, which included the establishment of a new agency, the Hawaiian Tourist Development Authority. Financed by revenue bonds and empowered to acquire title to land, clear or improve it, and lease it to private enterprise for development, it would plan projects throughout the territory. A legal maximum on the Territory's debt limit would prohibit its handling the project, the students learned, and no federal aid is available for such programs. No single private group could afford so great an enterprise.

The students retained present hotels, but located new ones so as to keep clear as much of the ocean view as possible. Buildings for professional and commercial use are in one central area, and large park and beach areas are set aside. All these ideas and many more have been incorporated in a 14 by six foot model of the redevelopment, which has a scale of 100 feet to one inch, with laminated cardboard sheets duplicating the topography. The highest point, 600-foot Diamond Head, is 60 sheets high.

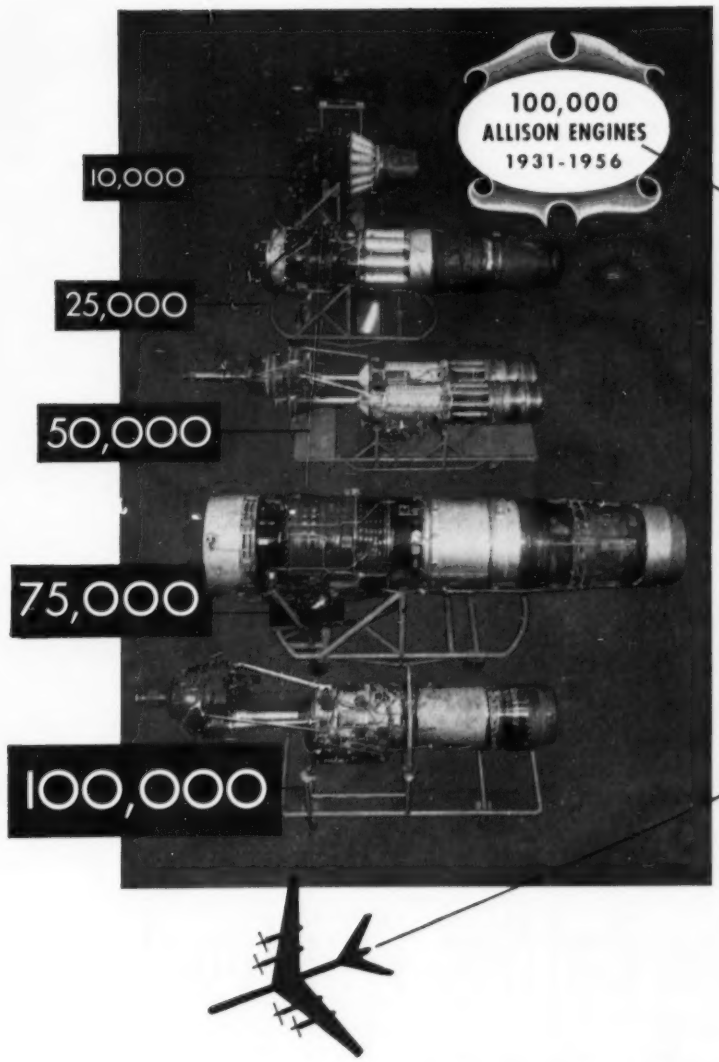
The blue sea, complete with waves is represented by translucent plastic sheets, over color which is graduated to show the different depths. On the model beach and in the water are poppy seeds, representing bathers. Oat seeds are pleasure craft; varicolored dill pickle seeds are automobiles. The students made the thousands of bungalows and houses of stiff paper, and for houses and office buildings used transparent colored acetate, cardboard, and corrugated plexiglas. A lacy plastic ear-ring is a marina restaurant, in the middle of a round pond. Wire screen represents masses of banyan trees and map tacks are palms. All this will be shipped to Hawaii for display and a brochure describing the project will be printed.

Katz Discusses Thermal Barrier

What will happen to commercial and military aircraft when the thermal barrier is broken? This subject is discussed by Professor Israel Katz of the Department of Thermal Engineering in the March issue of *Research and Engineering*.

In an article entitled "Power: the Key to Flight beyond the Thermal Barrier," Professor Katz writes that the key factor in this advance will be the power plant, which will dictate the configurations of the vehicle, as well as its lifting, propelling and cooling characteristics. In the future aircraft the power plant will be indistinguishable from engine and aircraft structures.

The article proposes a new scheme using highly integrated turbojet engine - airframe combinations. He analyzes the factors that limit conventional turbojet engine performance and suggests this solution: continuous induction of boundary layer air and its acceleration to a relative velocity slightly greater than that of the surrounding air stream.



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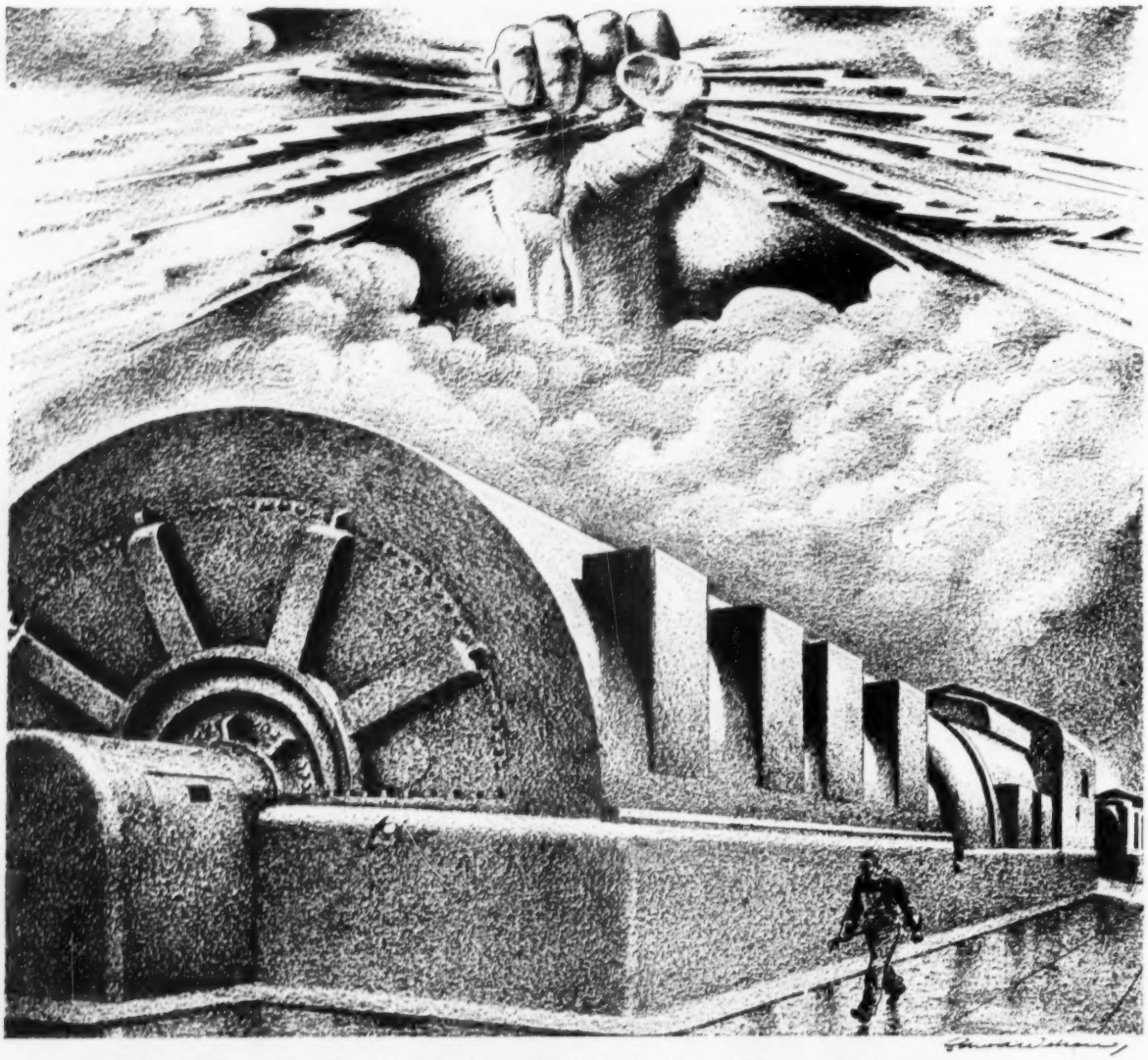

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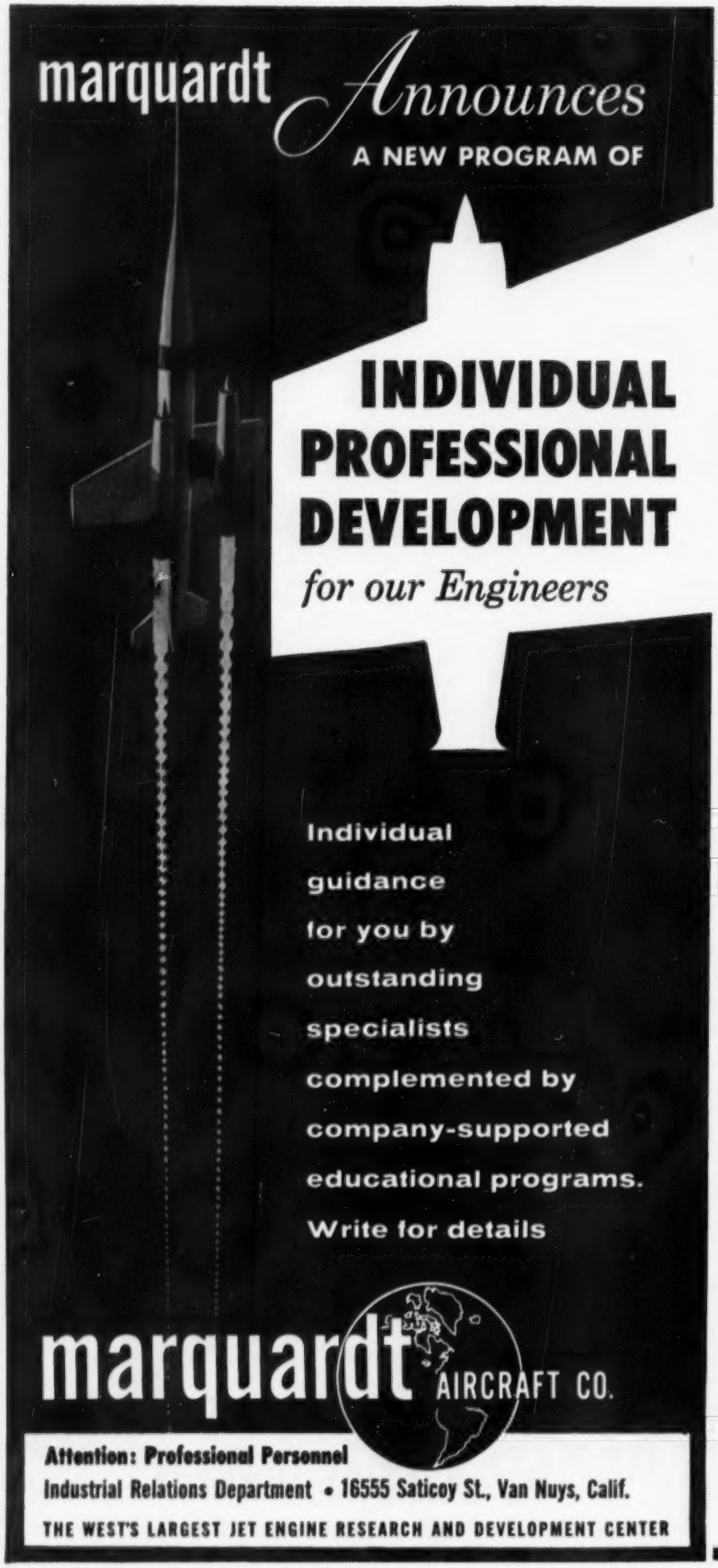

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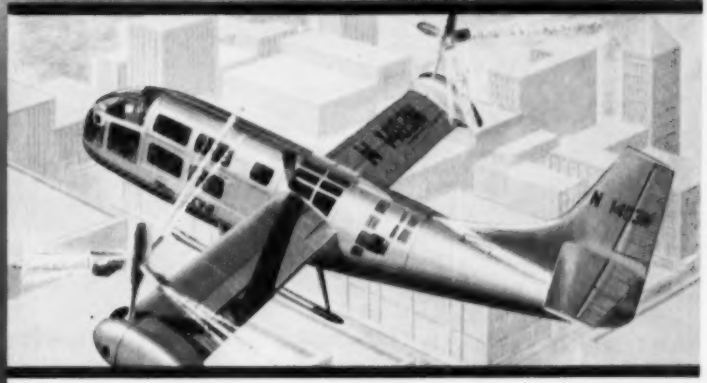

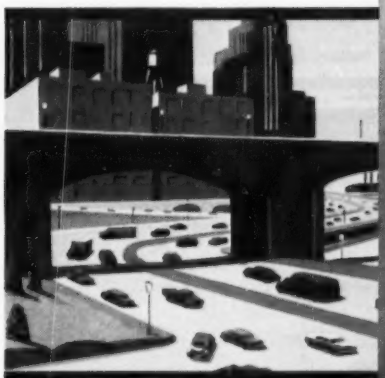

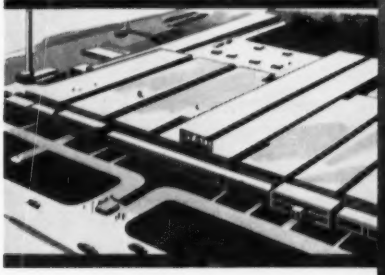

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